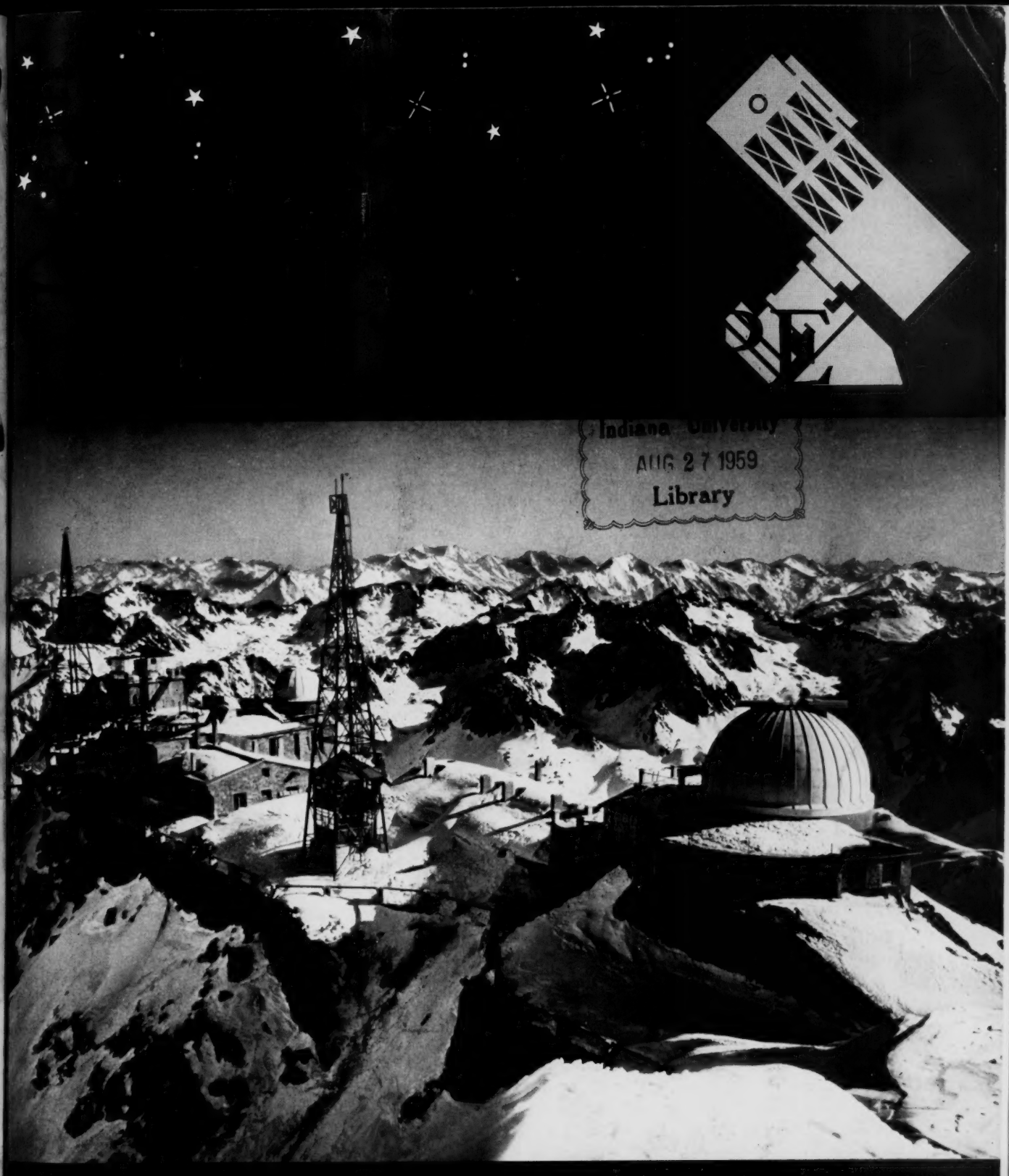

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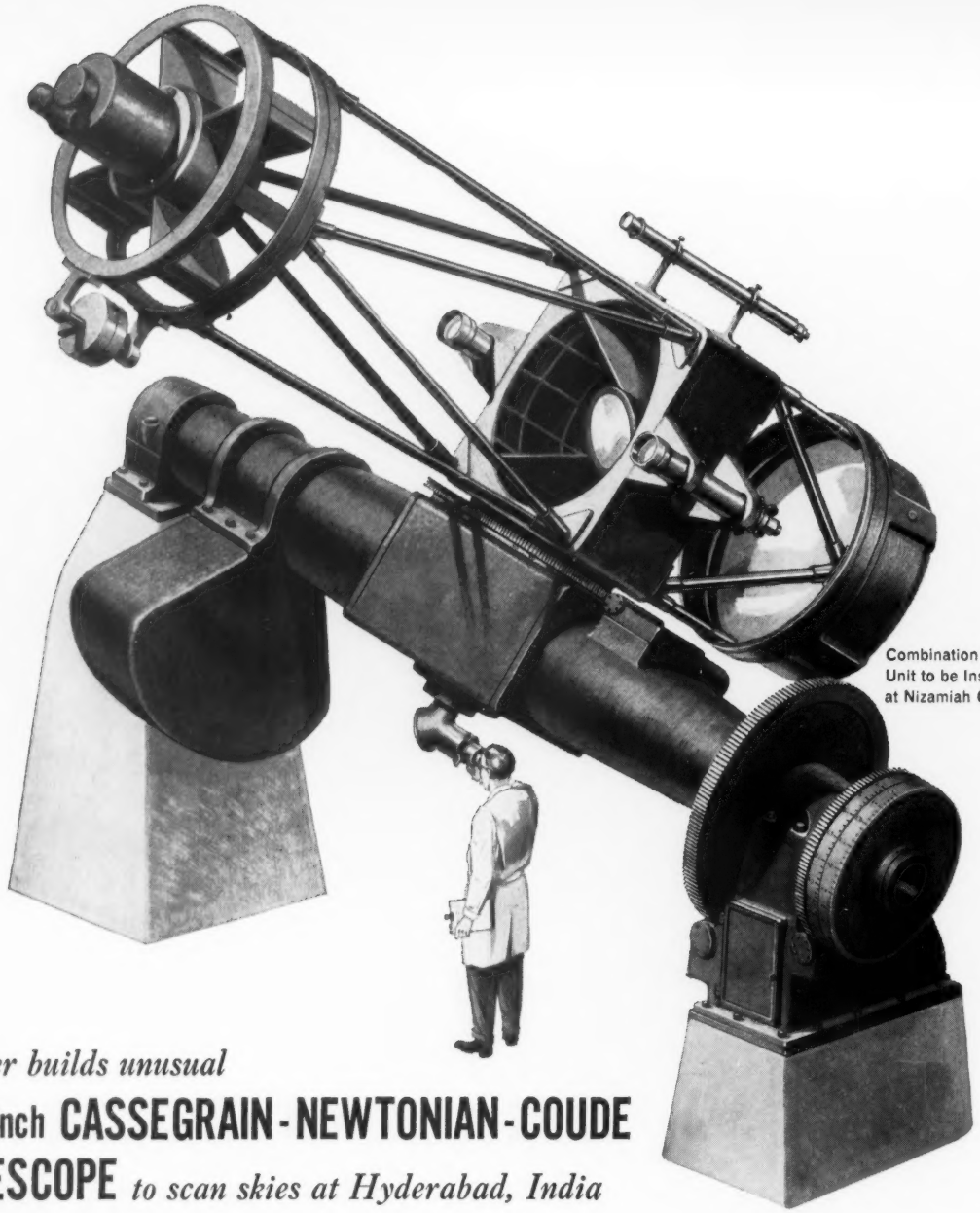

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Sky and TELESCOPE

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Vol. XVIII, No. 11 SEPTEMBER, 1959

CONTENTS

COVER: Pic du Midi Observatory, 9,400 feet above sea level in the Pyrenees Mountains of southern France, is a world center for planetary and lunar observing. In this view from the north, its buildings occupy an area about 400 feet long on the east ridge, slightly below the summit, from where the photograph was taken. Near the tower at the left is the upper end of a cable lift, nearly three miles long, which carries personnel and supplies from the winter sports resort at Mongie. The buildings between this tower and the dome of the 24-inch refractor at the right contain living quarters for about two dozen persons. Photograph from Henri Camichel. (See page 600.)

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Meteoric Satellite of the Earth?

ON February 9, 1913, a remarkable meteoric event was seen by many persons located all the way from Saskatchewan across North America and over the Atlantic Ocean to the equator. From a detailed scrutiny of observational reports, W. H. Pickering concluded that a cluster of fireballs had moved in parallel, nearly horizontal paths over some 5,700 miles.

This interpretation was, however, severely criticized by C. C. Wylie in 1939, who held that this was no procession of fireballs, but an intense shower, different meteors having been seen along various stretches of the 5,700-mile track. He calculated detailed orbital elements for one particularly spectacular and well-observed detonating meteor, seen by many people in Ontario.

A re-examination of the problem has now been published by John A. O'Keefe, of the National Aeronautics and Space Administration, in the April *Journal* of the Royal Astronomical Society of Canada. He shows that the radiant point in terms of which Wylie sought to explain all the observations was actually below the horizon at the locations of several ships in the mid-Atlantic from which the fireballs were observed. In addition, Wylie had discounted Canadian reports that indicated the flight appeared nearly level.

"No normal meteoric orbit will satisfy the observations," says Dr. O'Keefe. "The fundamental difficulty is that the observations indicate an orbit which follows the curvature of the earth over an arc of almost 90°. This is only possible if the orbit is nearly circular." He finds that the reports can be satisfied by a satellitic orbit around the earth, with a period of 90 minutes, orbital inclination of 51°.6, and eccentricity zero.

If this is the case, the meteoric procession of February 9, 1913, was the visible destruction of a natural satellite or satellites of the earth, descending into the lower atmosphere.

Dr. O'Keefe's paper contains an extended bibliography. Some historical notes on meteoric satellites of the earth were published on page 334 of the June, 1955, SKY AND TELESCOPE.

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Mars Observations at the Pic du Midi

HENRI CAMICHEL, *Pic du Midi Observatory*

THE PLANET MARS comes back to the same conditions of visibility every 15 or 17 years. Thus the last opposition, in November, 1958, was equivalent to the one of October, 1941, when the Pic du Midi Observatory began a program of planetary observations which is still being continued. As a 17-year cycle of observing has just been completed, this is an appropriate time to describe the Mars findings obtained at this institution.

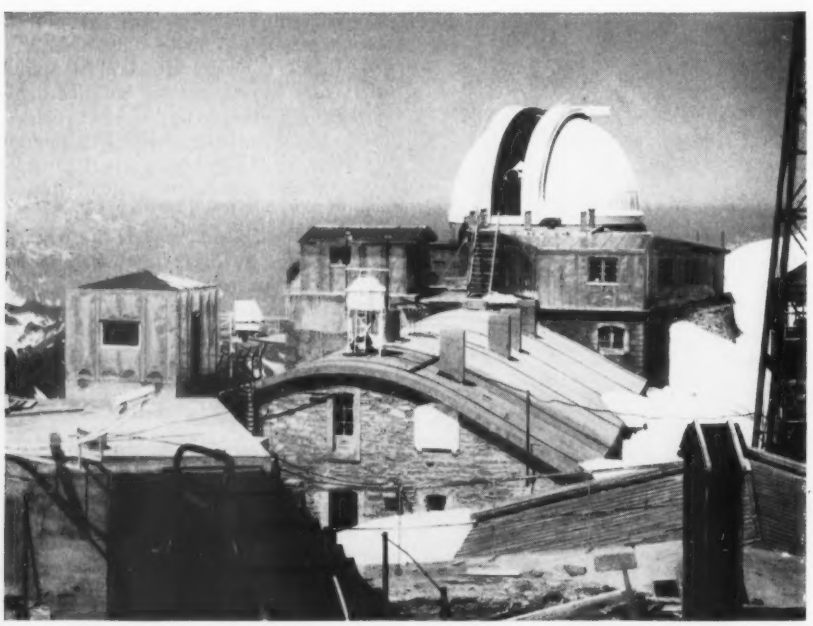
The earth's atmosphere is the enemy of good astronomical observations, and a telescope should be placed above as much of it as possible, especially the turbulent, dust-laden lower layers. On the Pic du Midi de Bigorre, in the French Pyrenees at an altitude of 9,400 feet, one-third of the atmosphere lies below the observer. While it is partially true that the presence of mountains causes turbulence and cloudiness, much depends on the local conditions. The location of the mountain in front of the main range of the Pyrenees very greatly reduces such handicaps. Of course, an isolated point suspended in air at the same elevation would probably have still more favorable conditions.

Pic du Midi Observatory from the south. The dome at the left is for the 24-inch refractor, the farther one for a reflector of equal aperture. Below in the distance are the plains of Gascony.

Many persons have exaggerated ideas of the hardships of life at a mountain observatory, especially in winter. Certainly, living is more difficult than at low-level stations, but the results obtained fully justify the difference. When I first planned to go to the Pic du Midi, almost all my friends told me that I would not be able to stand the cold, that even the dome would be frozen and not turn.

Actually, the climate at Pic du Midi is not so severe. In winter, temperature inversions are frequent here, making the difference in temperature between the summit and the lowlands much less than the theoretical difference of around 25° Fahrenheit. Last December, for instance, there were some nights when the temperature remained above freezing. Only rarely does one observe when it is as low as 5°, and during fine winter nights it is usually a not uncomfortable 15° to 32° F.

It is true that communications with the mountain are difficult in winter, and when I first went there in 1938 supplies had to be carried in on men's backs every two weeks. But now there is a cable lift and electric power, and life on Pic du Midi is nearly as comfortable as in a city. The disadvantage of this progress is that the presence of well-lit, heated buildings with many inhabitants removes us further from the observing conditions of an ideal isolated point suspended in air.



Through the slit of its open dome is seen the objective end of the 24-inch telescope. In addition to purely astronomical studies, investigations in the fields of cosmic radiation, meteorology, and biology are carried out here. All photographs with this article were supplied by the author.

For many years, astronomers had realized the desirability of erecting a scientific station on the Pic du Midi, among them John Herschel. The observatory was founded in 1882 by Gen. Charles de Nansouty and the engineer X. G. Vaussenat. Among early visitors to the mountain was the American astronomer Percival Lowell, in 1903, who was highly enthusiastic over its suitability for planetary work.

Around 1908, Benjamin Baillaud, then director of Toulouse Observatory, erected a double telescope on the Pic du Midi. It consisted of two instruments in the same rectangular tube, a 9-inch refractor and a 20-inch Newtonian reflector, both of 20-foot focal length. The reflector was used by F. Baldet and Count A. de la Baume Pluvinel during the opposition of 1909 to

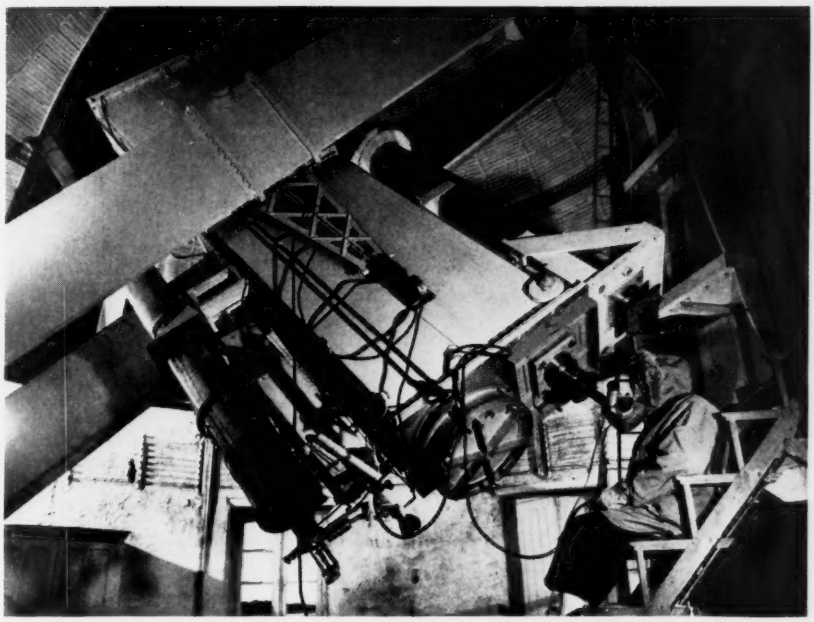
take Mars photographs of beautiful quality for that time. It was these good results and Dr. Baldet's enthusiasm about the seeing at Pic du Midi that encouraged me to go there for planetary observing.

But when I arrived at the observatory, the reflector was no longer in regular use, although for several summers Bernard Lyot had worked there and had photographed the solar corona with a coronagraph mounted on the tube of the double telescope. It turned out that the 20-inch mirror had lost its initial quality, being strongly astigmatic when I tried it. Moreover, even good reflectors seem to be surpassed by large refractors for planetary observations.

Therefore, in 1941 at Lyot's request, director E. Paloque of Toulouse Observatory provided a 15-inch objective of 20-foot focus which was installed in the tube of the Pic du Midi telescope that August. This excellent lens, made by the Henry brothers, was used in our first Mars observations. In 1943, it was replaced by a 24-inch f/30 visual objective lent by the directors of the Paris Observatory, E. Esclangon and A. Danjon. This objective, which was once employed with the large coude telescope at Paris, is in regular use here at Pic du Midi, and the 15-inch lens is now temporarily mounted in the same tube.

Because the 60-foot focal length of the 24-inch lens exceeds the 20-foot length of the tube, the light path had to be folded and light traverses the tube three times. This arrangement gives very good results, although the reflections from the two excellent plane mirrors (refigured by André Couder) slightly increase the diffused light, thereby weakening contrast.

Through the open slit of the dome can be seen the snow-covered Pyrenees. The instrument is one of the cluster mounted on the rectangular tube of the Baillaud telescope pictured at the top of this page.



A general view of the 24-inch refractor. The round cell (below center) holds an optical flat that folds back the light to a second flat at the upper end of the tube, which returns it to the eyepiece. To the left is the coronagraph assembly.

The Mars observations were begun by Lyot, M. Gentili, and myself. Later A. Dollfus joined us, and then J. Focas, an astronomer from the National Observatory at Athens. From the start, both visual and photographic observations were made. My colleagues worked mostly visually, while I concentrated on photography.

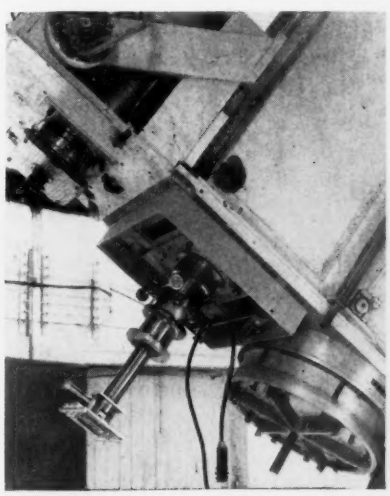
As a rule, the photographs are taken at regular intervals of about an hour, with the visual observations being made in between. Short exposures are desirable to catch the moments of good seeing, and to facilitate guiding the instrument. On the other hand, fast plates are grainy and have poor contrast — unwanted properties for planetary photography. If the image is enlarged enough to compensate for grain size, the exposures are about the same as with slower plates for prime-focus images.

Our experience is that best results are obtained with emulsions having good contrast and average sensitivity. Since the telescope objectives have been achromatized for visual light, panchromatic plates with a yellow filter must be employed. In practice, the emulsions I use most frequently are Kodak III-B and IV-B. The latter is preferable if the air is so steady that a longer exposure time is feasible.

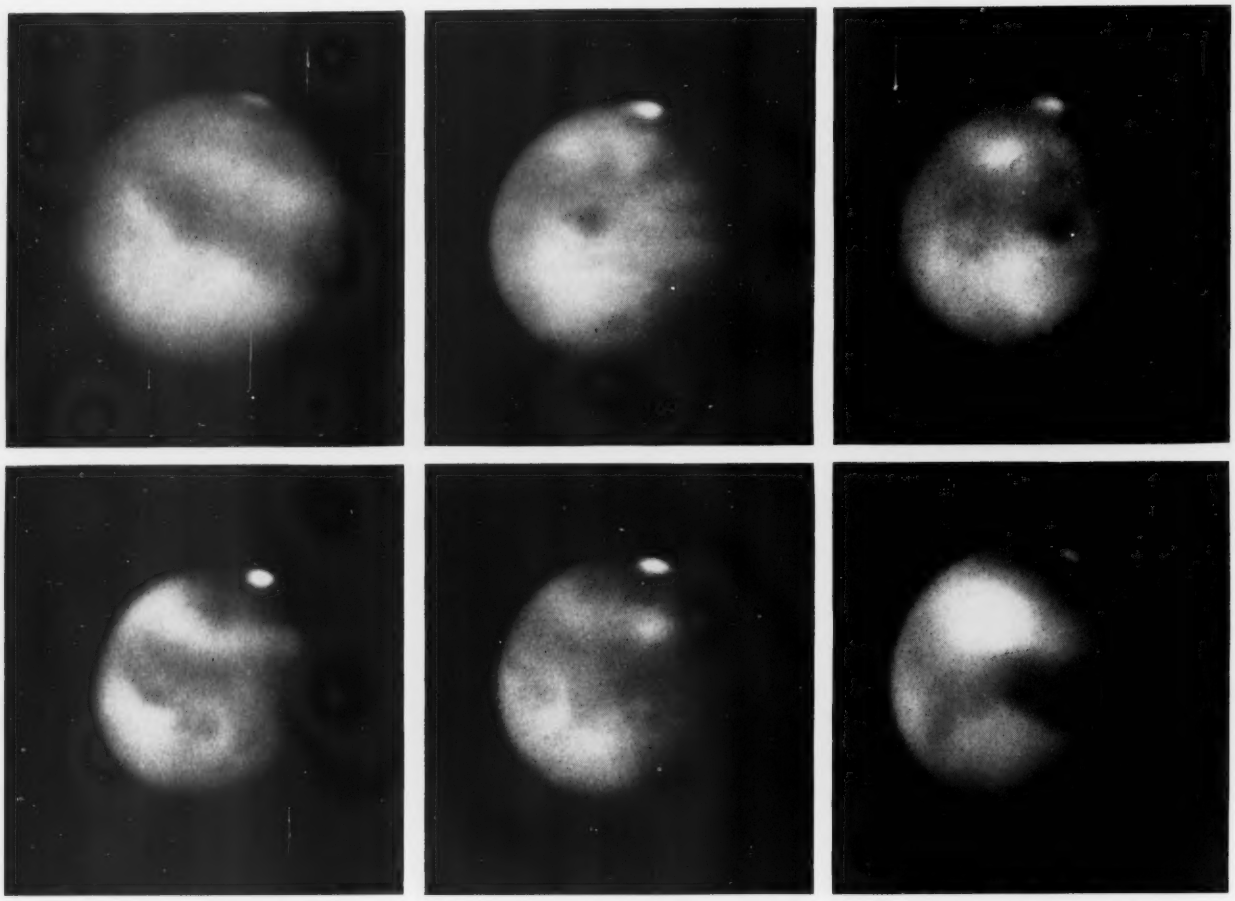
Choice of the emulsion determines the most suitable equivalent focal length, from considerations of grain and speed. Foci of 20 and even 60 feet are too short, so a Barlow lens was added, giving an equivalent focus of about 160 feet, requiring exposure times of $\frac{1}{3}$ to one second on III-B or IV-B plates. In 1941, when I was using slower, finer-grained plates, the adopted focus was 100 feet. Even with a 160-foot focal length, the diameter of Mars on the plate is only one-fifth of an inch!

The camera is focused by a reflex system, allowing the operator to watch the changing image quality and to take pictures only at the most favorable moments. The exposure must be guided if it is longer than one second. When the observer uses the 9-inch refractor as a guide telescope, he merely has to press against the side of the tube to keep the image fixed during the short period of the exposure.

On each $2\frac{1}{2}$-by-$3\frac{1}{2}$-inch plate, 19 expo-



The camera for photographing the planets is mounted at the eye end of the 24-inch, above one of the 20-inch flat mirrors whose cell is visible at the lower right.



Each of these six composite photographs of Mars was made by the method described in the text, from Pic du Midi negatives taken during September and November, 1956. The date, mean Universal time of observation, and longitude of the Martian central meridian are, from left to right (top row), September 13, 22:06, 242°; September 30, 22:58, 104°; October 1, 21:38, 76°; (bottom row), October 8, 21:23, 9°; October 8, 23:38, 43°; and October 13, 21:33, 326°. The brilliant south polar cap is prominent in all six views. Other conspicuous features include Solis Lacus, the large dark spot near the center of the top middle picture; and Hellas, the great white region above the center of Mars in the last picture.

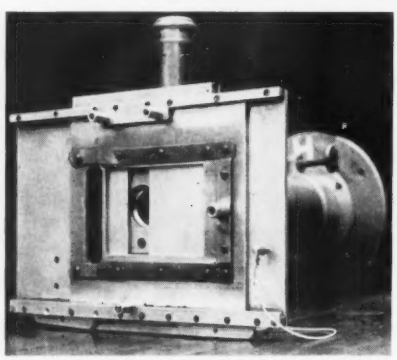
sures are made, arranged in four lines of five images; in place of the 20th image there is a mark to show the direction of the diurnal motion. In addition, the plate carries intensity calibration marks, used in determining plate contrast and making photometric measurements.

It is possible to minimize the harmful effects of grain by superimposing several of the best images (usually seven to 14) from the same plate, provided they are made within a short enough time interval, five minutes at most for Mars. The difficult and tedious task of combination was carried out at Meudon Observatory, originally by Lyot, next by Michel Hovine under the direction of Dollfus.

As they are superimposed, the images are enlarged to a scale of one second of arc per millimeter, furnishing a composite positive, from which a contact negative is made. The negatives facilitate reproduction of the pictures. The best of these composites have a resolution of 0.4 second of arc or better, sometimes even 0.3 second. Thus they show almost everything that can be observed visually with the 15-inch telescope.

In this way, a pictorial record of Mars at all its oppositions from 1941 to 1956 has been obtained. By consulting this collection of pictures, it is easy to trace the changing appearance of the planet in the course of an opposition, or to follow changes in the same region during successive Martian years.

From measurements of these negatives I determined the Martian latitudes and longitudes of about 260 surface features.



This is the simple camera attachment on the 24-inch refractor used by the author for his planetary photographs. The camera back has been removed.

It is evident that as Mars turns on its axis a surface spot will describe a portion of an ellipse, whose size, shape, and orientation will depend on the size of the planet and the direction of its rotational axis. From precise determinations of these trajectories for a few well-defined spots, especially Juventae Fons, I found that the diameter of Mars is close to 4,200 miles — in good agreement with earlier work — but the direction of the axis differs slightly from that generally adopted (see Sky and Telescope, November, 1958, page 25).

For each opposition, a map has been drawn from our photographs by the Italian astronomer G. de Mottoni. Careful study of the negatives allowed him to recognize the effects of the Martian atmospheric veil, and to enter on his map only features of the solid surface, with their average appearance for the opposition. Comparing the maps for different years shows the variations from one opposition to another. Also, by comparing the negatives with those maps, it is easy to pick out the Martian clouds.

A supplementary map was prepared, showing only the surface features that appeared to be stable and permanent

The intricate surface markings of Mars at its 1941 opposition are depicted in this map drawn by G. de Mottoni from photographs obtained at Pic du Midi by B. Lyot and the author. For names of features see page 23 of the November, 1958, issue.

during the years of observation. This map was used as the base of the new system of Martian nomenclature adopted by the International Astronomical Union last year. It was reproduced in the issue of SKY AND TELESCOPE referred to above.

Measurements of the relative contrast among various regions on Mars have been made on the Pic du Midi negatives by Focas, using a new type of photometer invented by Dollfus. Focas could thus prove the existence of a zone of darkening, starting from the poles at the end of Martian winter and progressing to the equatorial zone by the beginning of summer. This phenomenon had long been known visually, but the series of photographic records allowed its existence to be verified and the measurement of its rate to be made.

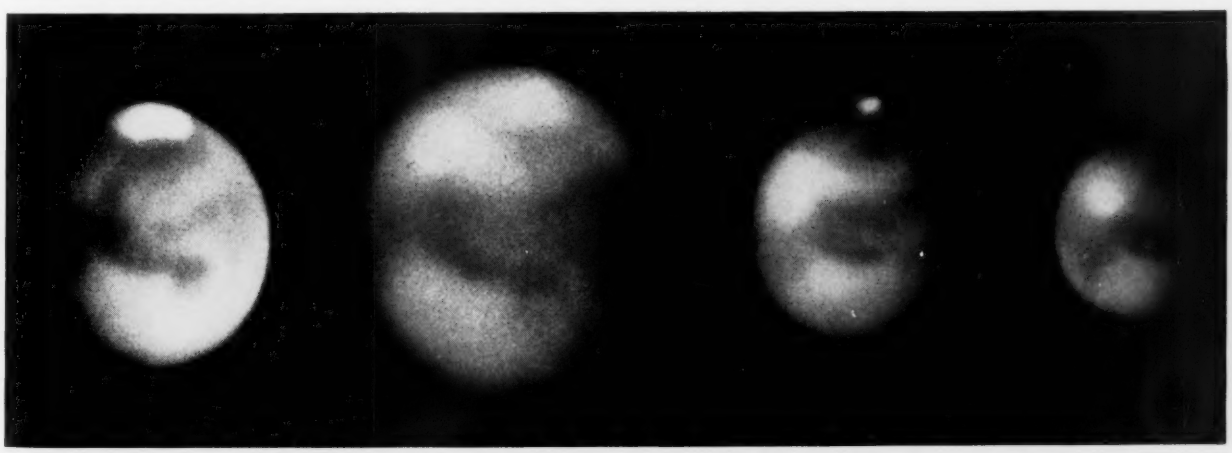
As a basis for Martian topography, photography has many advantages, especially in furnishing with minimum observing time a permanent record that can later be studied and evaluated by different persons. Photographs give an accurate delineation of the appearance of the planet, allowing weak differences in contrast to be discerned more easily than by visual observations.

Nevertheless, the eye has an undoubted advantage when it comes to detecting very delicate details at the limit of resolution of the telescope. Therefore, visual observations and drawings are necessary to supplement the photographs. On good nights at Pic du Midi, it is possible to separate visually Martian markings 35 miles apart, corresponding to the resolving power of the 24-inch objective.

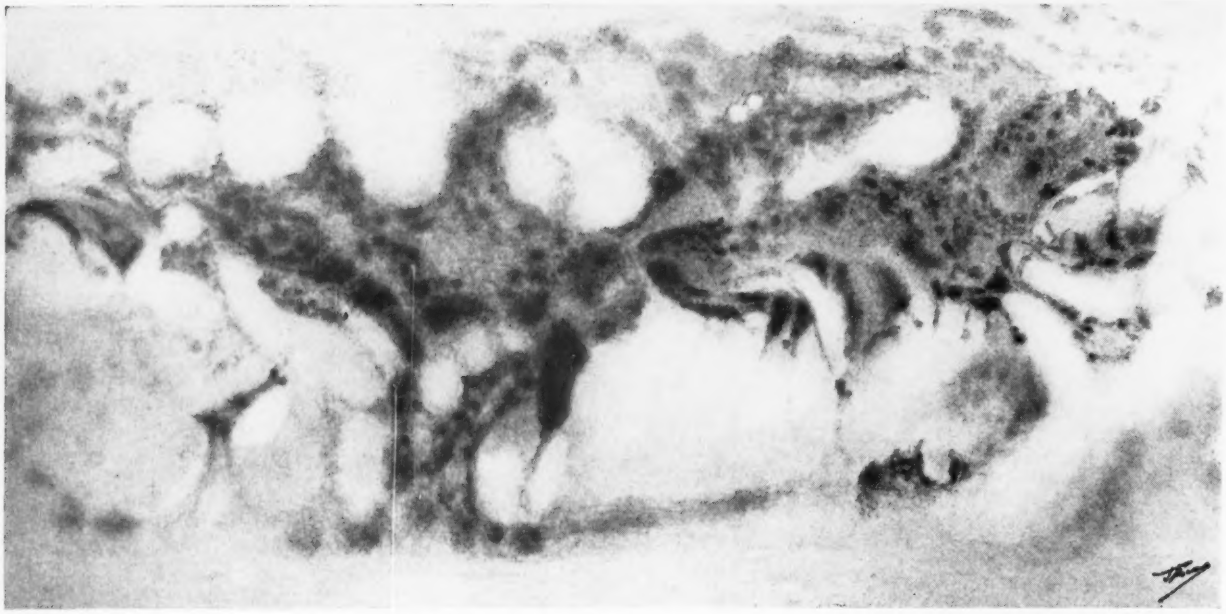
Three types of visual observation deserve special mention. First, the same photometer used for measuring the negatives has been employed directly at the telescope, giving more precise results. Second, a wide-field double-image micrometer invented by Dollfus has been used to measure the diameter of Mars and to determine its oblateness.

Finally, visual measurements of polarization have been made with a Lyot polarimeter, from which the polarization of an area about 600 miles across can be determined with a precision of one or two thousandths. The results obtained for the bright ocher regions are well explained on the supposition that they are covered by a powdery material like pulverized limonite (an oxide of iron). The dark spots, also dusty, show a seasonal variation in polarization. Suspended in the Martian atmosphere are clouds and white veils of ice crystals, sometimes so thin that they are revealed only by their polarization. There are also equatorial sunrise and sunset fogs, diffusing ultraviolet light and having the polarizing properties of droplets about two microns (0.00008 inch) in diameter.

What can be deduced from the long series of Pic du Midi observations regarding the famous Martian canals? The answer is, in my opinion, that they do not exist, at least not in the form they are so often drawn. When observing conditions are favorable, they are resolved into numerous tiny spots, more or less aligned, or they correspond to the boundaries be-



Four photographs, all to the same scale, show the variation in the apparent size and the phase of Mars during 1956. They were taken with the 24-inch refractor by the author on July 31st, September 7th, October 11th, and November 17th of that year, respectively. The second view is of Mars on the date it was closest to the earth (35.2 million miles), when clouds in the planet's atmosphere veiled the south polar cap. The other three pictures show strikingly the shrinkage of the polar cap as the Martian season advanced. The same face of the planet is presented, allowing comparison of dark markings.

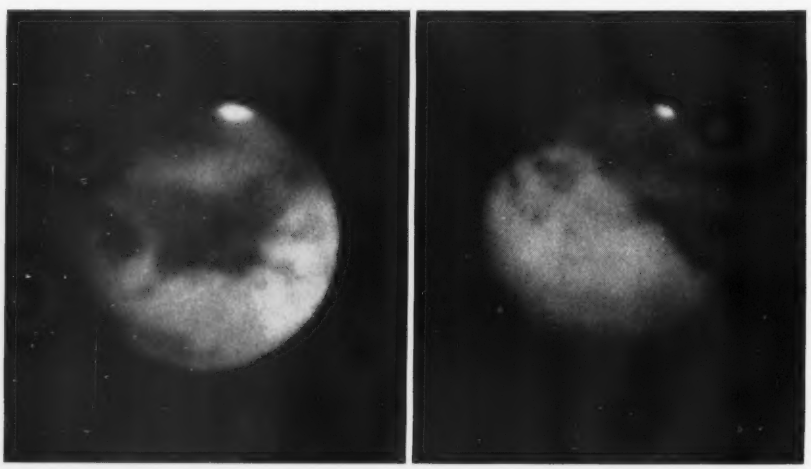


This map of Mars in 1958 was compiled by J. Focas from visual observations with the Pic du Midi 24-inch refractor at 1,200x. It affords an interesting comparison with the chart on the preceding page. Note the extreme wealth of fine detail revealed with a resolving power of about 0.2 second of arc. From "Travaux de l'Observatoire du Pic du Midi," No. 9, 1958.

tween regions differing slightly in brightness.

It is not when the finest details are visible that the canals may be seen. One proof is furnished by the following observation. In 1941 we found that the west point of Meridiani Sinus is double. The region is one of the most unchanging on Mars. Moreover, this double aspect has been repeatedly seen at Pic du Midi in later oppositions, and the 24-inch telescope has verified it precisely. Probably this doubling has always existed and was previously missed because of unfavorable observing conditions. The duplicity was first detected with the 15-inch telescope. Atmospheric turbulence at lower altitudes would have reduced the resolving power of the 15-inch objective to barely that of a 12-inch. While we often discern this double feature of Meridiani Sinus but see very little of the canals, other observers draw many canals but do not notice the doubling.

Our results with Mars show the great value of planetary observations from altitudes like that of the Pic du Midi. Such an observing site also presents great advantages for many other astronomical studies. It is hoped that the program so successfully begun under Baillaud and carried on at present under director J. Rösch will be further developed to the advantage of astronomers in many fields.



These two composite photographs of Mars during its close approach of 1941 were made from exposures on September 27, 3:36 UT (left), and October 19, 23:20. The large dark marking central in the first picture is Mare Erythraeum, with Solis Lacus just coming on the disk at the right. In the second photograph, Solis Lacus is at the far left, and Mare Cimmerium is the large, very dark feature at the right. In all pictures of Mars with this article, south is above.

THREE NEW SUPERNOVAE

About a year ago at Mount Wilson and Palomar Observatories, Allan Sandage compared two plates of the spiral galaxy NGC 23 taken on August 23rd and October 23rd in 1955. They had been made with the 200-inch telescope for use in the Hubble memorial atlas of galaxies, and are reproduced in the April issue of the *Publications* of the Astronomical Society of the Pacific.

On the second photograph a prominent 16th-magnitude star appears, absent on the first plate, and situated about 14 seconds of arc northeast of the center of the galaxy. This supernova must have been within 60 days of its maximum light, as that was the interval between photos.

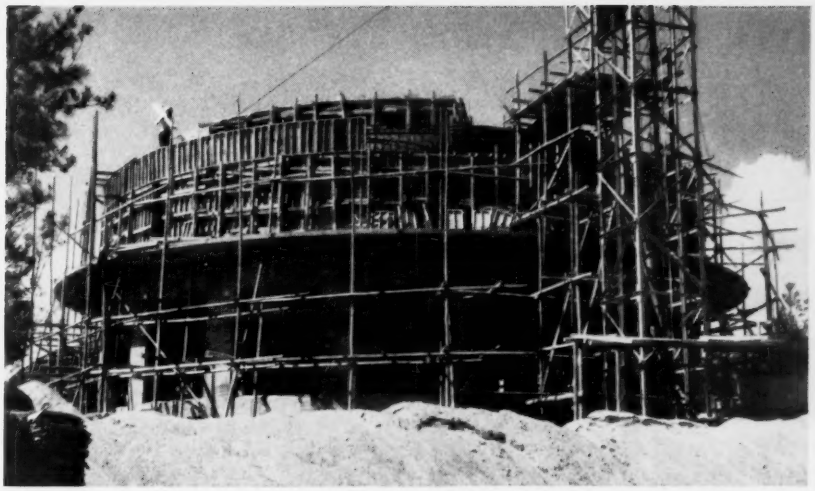
On the basis of the observed red shift of NGC 23, 4,790 kilometers per second (when corrected for the sun's motion), and a Hubble constant for the velocity-distance relation of 75 kilometers per second per million parsecs, Dr. Sandage estimates the galaxy's distance as about 210 million light-years. The visual absolute magnitude of the supernova at maximum should have been somewhat brighter than −18. This is 1½ billion times as luminous as the sun, and about as bright as many entire galaxies!

On June 28, 1959, two supernovae were discovered at Mount Wilson and Palomar Observatories by M. L. Humason. One appeared as a 12th-magnitude star in Pegasus, about 30 seconds of arc northwest of the 10th-magnitude galaxy NGC 7331. The other, of the 13th magnitude, occurred in a very small, faint galaxy in Virgo. Spectra of both objects, obtained by J. L. Greenstein, contained wide, very shallow features.

A New Observatory in Japan

MASASI MIYADI

Tokyo Astronomical Observatory



A picture taken in May, during construction of the building that will house the 74-inch reflecting telescope of the Okayama Astrophysical Observatory in Japan. The station will also have a 36-inch reflector.

WITHIN VIEW of the inland sea Seto-naikai, work is under way on a new observatory atop Mt. Chikurin, near Kamogata in Okayama prefecture, about 500 miles southwest of Tokyo. This branch station of the Tokyo Astronomical Observatory is destined to become the center for astrophysical research in Japan. Its facilities will be available to all Japanese astronomers.

When construction was begun on its two domes last December, the station was formally named the Okayama Astrophysical Observatory. Initially there will be two major reflectors, a 74-inch and a 36-inch, together with a main building for offices and laboratories, housing for observers, and a small museum for visitors. The two telescopes are expected to be installed in the middle of 1960.

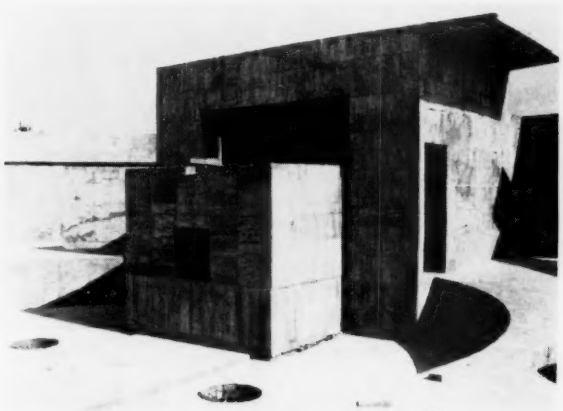
Several years ago, Y. Hagihara, at the time director at Tokyo, proposed a large reflector for astrophysical research in our country, and the Scientific Council of Japan recommended to the government that such an instrument be constructed. In 1954, the Diet approved the budget for the 74-inch telescope and other auxiliary equipment. It should be noted that P. Swings, then vice-president of the International Astronomical Union, had written the Diet a letter of recommendation for the project.

In 1955, the 74-inch was ordered from Grubb Parsons and Co. in England, as well as three spectrographs from Hilger, Watts and Co. The first spectrograph is for the coude focus, with dispersions of eight and 20 angstroms per millimeter; the second, for the Cassegrainian focus, with dispersions of 17 and 57 angstroms at the hydrogen-gamma line; and the third, of 45 at 3500 angstroms. In addition to spectroscopy, the telescope will be used for direct photographic work at its Newtonian focus.

The 36-inch reflector, designed and constructed by the Nippon Kogaku Co., will be utilized mainly for photoelectric work.

Two years were needed for selecting the observatory site. First, three locations were chosen, and then a year was spent observing with 4-inch telescopes for comparisons of seeing, scintillation, and limiting magnitude. The selection of Okayama was so enthusiastically received by the local people that the prefecture government offered to finance land procurement, the expenses of building a road, providing electric power and water supplies, and building the museum. About 120 acres of wooded land were secured on Mt. Chikurin, which is some 1,200 feet above sea level.

The climate is fairly mild, and the site is not subject to very high winds or excessive snow, as there are mountain ranges along its northern and southern sides. Although the observatory faces the sea, it is about six miles from the coast. The 74-inch reflector will be located at longitude 133° 35′ 47″.3 east and latitude +34° 34′ 26″.1.



The coude-focus laboratory for the 74-inch telescope will contain a high-dispersion spectrograph for stellar work. The Okayama Astrophysical Observatory is the first installation of its kind in Japan. Photographs with this article were provided by the author, who is the director of the Tokyo Astronomical Observatory.

CORNELL TO ERECT RADAR TO OBSERVE VENUS

A giant radar antenna, 1,000 feet in diameter, will be constructed in a limestone sink in Puerto Rico by Cornell University for studies of cloud-covered Venus and the electrical properties of its atmosphere. Although the detector is still in the planning stage, it is expected to be in operation by April, 1961, when Venus comes to inferior conjunction, closest to the earth.

The antenna will be able to pinpoint the planet's distance within 500 miles, optical methods giving errors many times that amount. Repeated radio observations might reduce this to 100 miles. These measurements would give astronomers a greatly improved value for the scale of the solar system (SKY AND TELESCOPE, May, 1959, page 384).

In addition to Venus, the radar will be used on the moon and sun, Mars, and possibly Jupiter. The low latitude of Puerto Rico favors such observations, for at times the planets pass near the zenith. The antenna may also track space vehicles. The project is under the direction of William E. Gordon, of the Cornell engineering department.

METEORITICAL SOCIETY MEETING AT HARVARD

At the invitation of the Smithsonian Astrophysical Observatory, the 22nd meeting of the Meteoritical Society will be held at Harvard Observatory, Cambridge, Massachusetts, September 10-11. The sessions, which are open to the public, begin at 9 a.m. in the observatory lecture hall. Chairman of the program committee is F. Behn Riggs, Jr., of the Smithsonian.

The Occultation of Regulus by Venus in July

GERARD DE VAUCOULEURS, *Harvard College Observatory*

THE PLANET VENUS occulted the 1st-magnitude star Regulus – Alpha Leonis – on July 7, 1959. This very rare phenomenon was observed from Europe, Asia, and Africa, with less favorable conditions occurring in eastern North and South America.

As reported in this magazine for July (page 483), Harvard Observatory organized several expeditions to various observatories in southern Europe and the Near East, and arranged co-operative observing in South Africa and India. At a number of these locations visual, photographic, and photoelectric observations were successfully carried out.

At the time of occultation, as seen from southern Europe, Venus was close to meridian transit and about 30 degrees from the zenith. In South Africa, it was about one hour west of the meridian and 35 degrees from the zenith, while in Asia Minor it was two hours past the meridian. The phenomenon was therefore ideally placed for observation in these parts of the world. The occultation was central for observers in the middle of Africa, nearly grazing in Scandinavia and western Russia. An intermediate chord of the disk of Venus was intercepted by the path of the star for observers in southern Europe.

Venus' apparent diameter, as given in the *American Ephemeris,* was 28.3 seconds of arc, with the crescent's line of cusps at a position angle of 20.0 degrees. The planet's motion was in position angle 118.02 degrees. One or more of the following observing programs were attempted at each of the Harvard expedition stations.

Visual. In order to determine the exact path of the star with respect to the planet's disk, micrometer measurements were made of the successive positions of Regulus in relation to the horns of the crescent. These measurements would indicate the position angles of the points of contact on the limb of the planet. In addition, the various phases of the disappearance and reappearance of the star were to be timed as accurately as possible.

Photoelectric. Observations with a photoelectric photometer and a time recording device were very desirable, as they would provide a light curve of Regulus during the critical seconds that it was passing behind the upper layers of Venus' atmosphere. Differential refraction caused a weakening of the star's light and presented a unique occasion to determine the scale height from it. The scale height is defined by the formula

$$H = RT/mg,$$

where R is the universal gas constant, T is the mean absolute temperature in the observed region of the atmosphere of mean molecular mass m, and g is the acceleration of gravity at Venus' surface. From H the ratio of mean temperature to molecular weight at the observed level above the planet's surface can be computed.

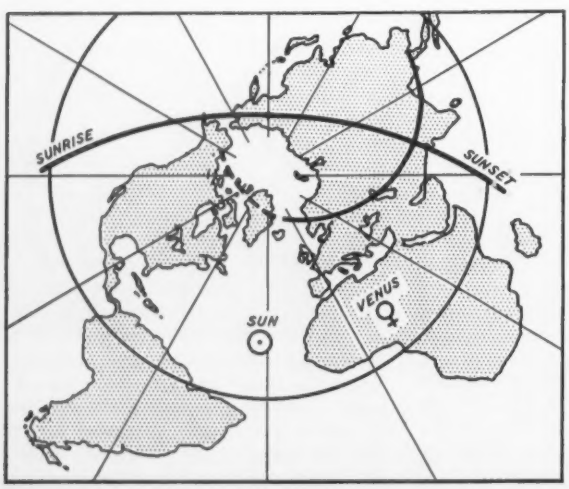
The photoelectric measures were secured through very small field diaphragms isolating the image of the star, aided by interference filters passing only a narrow band of the spectrum centered on the ionized calcium K line in the near ultraviolet. Since Regulus is a hot star of spectral type *B7*, it has no K absorption line in its spectrum, being bright in that region. Venus and the earth's atmosphere, on the other hand, reflect the solar spectrum, which has a very strong K line and is dark where Regulus is bright. The filters, therefore, increased the contrast between the star and its sky background.

In addition to photometers already available at some of the observatories, three of them were specially designed and built in the Harvard Observatory workshop under the supervision of H. C. Ingrao. The interference filters were made by Baird-Atomic, Inc., to transmit about 50 angstroms between half-maximum points, their peak transmission being about 50 per cent.

Cinematography. Motion pictures were taken through red or blue filters, depending on whether the telescope was visual or photographic. At frame rates of the order of four to six per second or more, the filming was to start about one minute before disappearance, then be interrupted until one minute before reappearance. The emulsions were Eastman Tri-X or I-D (2) for red light, and II-O or 103-O for blue light. Most stations used N-9 cameras lent by the Air Force Cambridge Research Center, which, along with Boeing Airplane Co., supported the Harvard program. Nikor Co. lent eight 16-mm. film processing units.

Although full reports have not been received, some preliminary information is available from the Harvard expeditions and from other observatories.

Venus and Regulus as they appeared a few seconds before the star vanished at the dark limb of the planet. Owen Gingerich obtained this picture at American University Observatory in Lebanon. It is a composite print of several negatives.



The relative positions of Venus and the sun at the time Regulus was occulted are seen here projected onto the earth. The sun was on the meridian slightly west of longitude 30°, while Venus was near the zenith in northern Nigeria. The equator is indicated by the nearly complete circle. The arc from Greenland to Thailand marks the northern limit of visibility of the occultation, which was seen under unfavorable circumstances in North America due to the low altitude of Venus.

At Boyden Observatory, Union of South Africa, a photoelectric record was secured by H. Haffner and his staff, using the 60-inch reflector stopped down to 17 inches, a K-line filter, and a field diaphragm of five seconds of arc. The 13-inch photographic refractor was also used for photometry, with a blue filter and nine-second diaphragm. Somewhat overexposed film was obtained with an N-9 camera attached to the 10-inch photographic refractor. Overcast skies prevented observations by F. Franklin at the 27-inch refractor of the Lamont-Hussey Observatory.

In Beirut, Lebanon, at the observatory of American University, O. Gingerich and his group made a long series of micrometer observations with the 5-inch finder telescope. Operation of the camera on the 12-inch refractor was begun prematurely, because of interference by passing clouds, and the disappearance was missed by a few seconds.

Harvard director Donald H. Menzel had gone to the Astrophysical Observatory, Catania, Sicily, at the invitation of M. G. Fracastoro. Satisfactory visual observations of both immersion and emersion were made with the 12-inch visual refractor. M. Snowden, who operated the motion-picture apparatus on the 13-inch photographic refractor, found his film badly fogged by hazy sky.

Rain and overcast skies prevented all observations at the Vatican Observatory's Castel Gandolfo station, where J. Wolbach and J. Noyes were located, while similar conditions prevailed at Asiago, where F. West was stationed. But at the fourth Italian station, at Merate near Milan, R. Doyle and H. Ocker reported valuable movies with the large visual refractor. Photoelectric observations were not possible through the 40-inch reflector.

Director R. Carrasco received a number of observers at the University of Madrid Observatory in Spain. The weather was good, but Mr. Ingrao's camera mechanism failed at the critical time. Visual timings were procured, however. Smithsonian Astrophysical Observatory astronomer J. A. Hynek's personal observations were visual (not photoelectric as implied on page 554 last month), with a 5-inch telescope. R. Hosfeld and G. Nielson, members of his party, used the twin primary telescope of the observatory for photoelectric and photographic observations, being bothered by local seeing conditions and by mechanical difficulties.

Dr. Hynek was in a separate dome only 100 yards from the main one, yet his seeing conditions at occultation time were excellent, attesting to the local nature of atmospheric "boiling" in that case. To guard against mechanical failure during the visual timings, he used two tape recorders and two independent sets of time signals, as well as a stop watch. Duration of the occultation was 11 minutes, 4.4 seconds, with mid-occultation at 14:25:09 Universal time.

Mr. Hosfeld obtained a photographic record, using a K-line filter, with individual time frames one second apart and very close to the immersion and emersion. The photoelectric program was, however, unsuccessful.

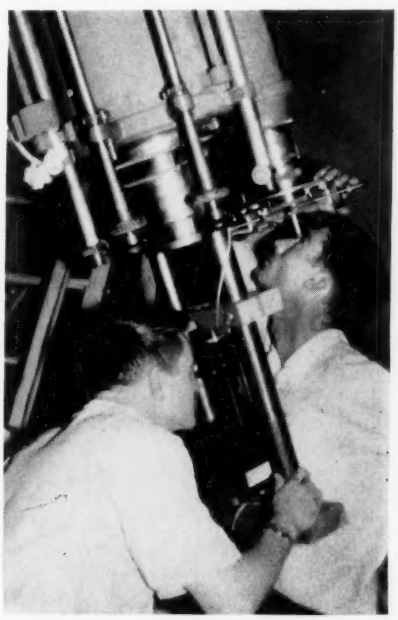
At the Péridier Observatory, Le Houga, France, the Harvard observers (Antoinette de Vaucouleurs, R. Levy, and the author) were favored by clear skies. I secured good visual timings with the 8-inch visual refractor, while a photoelectric light curve was simultaneously obtained through an 8-inch photographic refractor on the same mounting. A K-line filter and eight-second diaphragm were used. The N-9 camera was attached to a 12-inch reflector, but the film jammed after running only a few feet.

This brief listing of the fortunes and mishaps at the various stations can hardly indicate the enormous amount of hard work by the expedition members and the Harvard and Smithsonian staffs in preparing the program. The observers had to work strenuously during the precious few days available to set up and test their equipment on location, but at all the stations the directors and staffs spared no effort to insure success.

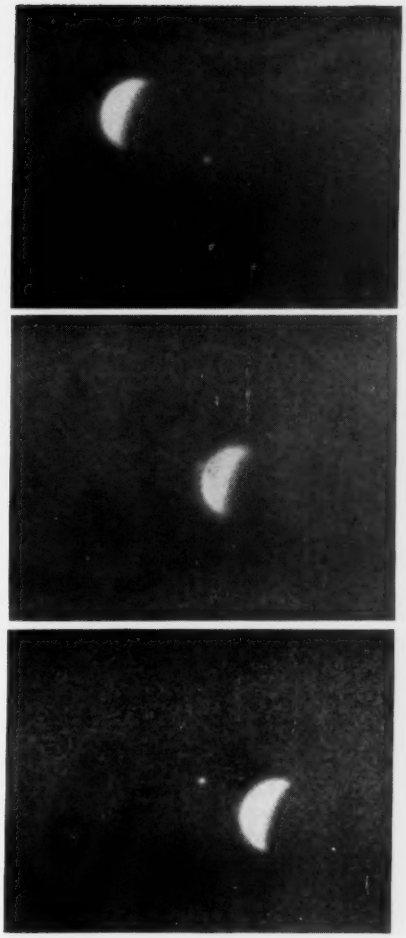
Other reports received recently indicate that clouds interfered with observations at the Union Observatory, Johannesburg, South Africa, where W. S. Finsen had made excellent preparations for filming the occultation through the 26½-inch visual refractor. Visual timings, however, were obtained at the Hartebeespoort Annex by T. Walraven, J. A. Bruwer, and their colleagues. Cloudy weather also prevailed at the National Observatory in La Plata, Argentina.

Among European observers, many of whose timings have been announced in International Astronomical Union circulars, was M. Minnaert, of the Sonnenburg Observatory, Utrecht, Netherlands, who writes:

"The occultation of Regulus by Venus was observed at Utrecht under good conditions, the sky being entirely clear. Two telescopes were used, a 25-cm. Merz refractor and a 40-cm. reflector. In the refractor, at 14:21:23 UT, Regulus' image became blurred, fainter, and at 14:21:31.4 it disappeared. At 14:29:25.2 the star was again visible, the first seconds after its apparition probably having been missed. For another three seconds the brightness



On the left is Mr. Gingerich at the Air Force N-9 camera used for motion pictures. It was attached to the 12-inch Brashear refractor of American University. At the right Mark Lesley is making micrometer observations with the 5-inch guide telescope.



Despite interference by clouds, W. S. Finsen and his staff at the Union Observatory in South Africa were able to obtain these pictures of Venus and Regulus. The 26½-inch visual refractor was used. At the top, Regulus is seen prior to its disappearance. In the middle, Regulus has just reappeared after having been occulted for approximately 13 minutes. The other observing sites in South Africa included the Boyden Observatory, in Bloemfontein, and the Lamont-Hussey Observatory.

The building and dome of the 8-inch refractors at Peridier Observatory. The photographs on this page are from the author's Kodachromes.

of the star seemed to increase further.

"In the reflector the image appeared blurred and fainter at 14:21:21.4, with disappearance at 14:21:31.2. Regulus reappeared at 14:29:22.5, and no increase in brightness was noticed thereafter. The moment of immersion seems very well established. The two telescopes were only about 85 feet from each other."

In the absence of complete reports from the various Harvard expeditions, I can only discuss in detail our work at the Péridier Observatory. The director, M. J. Péridier, generously placed his personnel at our disposal and gave us enthusiastic assistance. Our success resulted considerably from his preparations in advance of our arrival.

The bright yellow crescent of Venus and the dancing, twinkling image of Regulus made a pretty sight on the blue-gray background of the daytime sky, as seen with a power of 300 through the micrometer attached to the 8-inch visual refractor. However, the observer had little time to enjoy the spectacle, for with one hand he operated the pushbuttons for the right-ascension slow motion to keep the star centered on the crosshairs, and in the other hand he kept ready the bell-type button used to signal and record on the tape the quick succession of events during the occultation's fading phase.

Obstruction by the micrometer wires and irregular seeing – often poor, occasionally improving – caused continual fluctuations in the apparent brightness of the star. Because of this and the unavoidable element of surprise, the very beginning of the fading phase was missed, and I first noticed that the star was fading at about 14:20:11 UT, when it had already dropped by about one magnitude, according to the photoelectric recording. In a matter of about two or three seconds the star was gone.

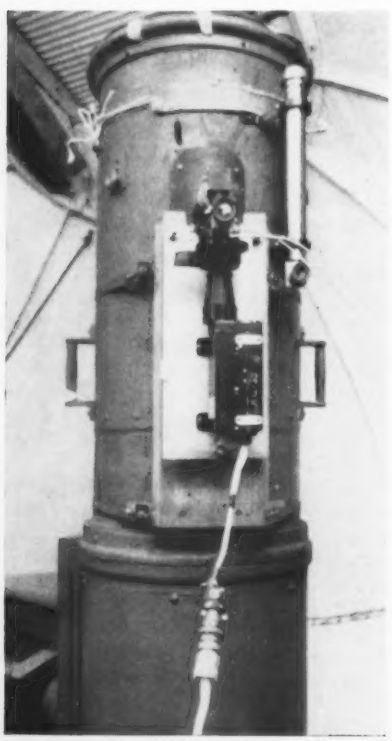
We immediately sent word to the other group of observers at the 12-inch reflector to stop filming. Unfortunately, as it turned out later, and to Mr. Levy's great dismay, the camera had stopped recording much earlier because of a malfunction of the magazine.

Then, during the interval between immersion and emersion, we telephoned Paris Observatory to obtain from its talking clock an additional check on our mean-time clock. The clock signals were, of course, carefully and repeatedly compared with radio time signals both before and after the event. We simultaneously impressed on a four-channel Brush recorder the short-wave time signals from BBC in London and MSF at Rugby, England, from WWV near Washington, D. C., and from the Paris Observatory talking clock.

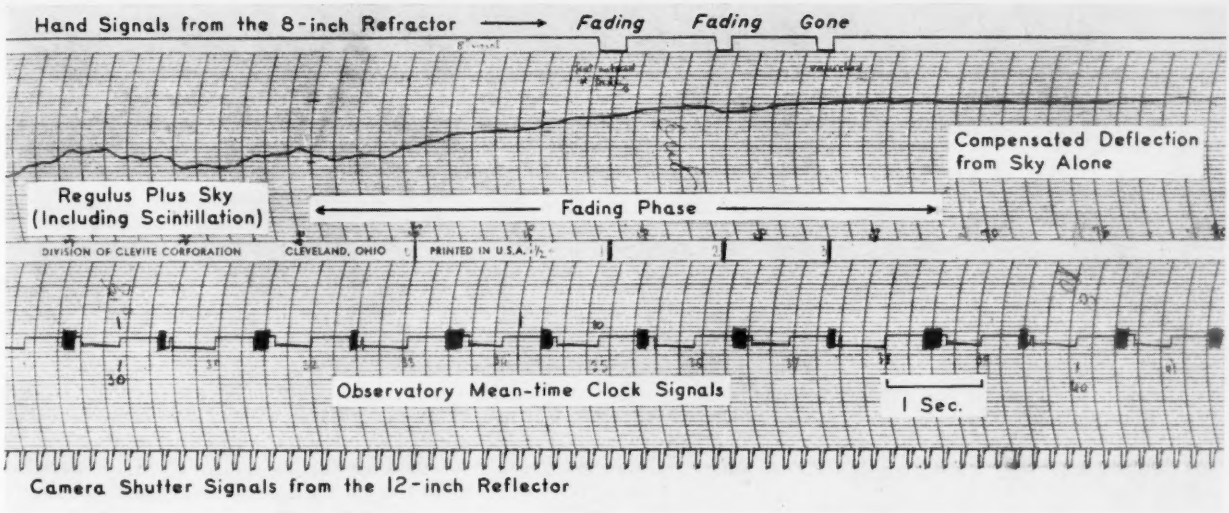
Resuming the visual watch with the 8-inch, I first uncertainly suspected the star, very faint in the boiling zone at the bright limb of Venus, but only at 14:30:29.4 was the first definite glimpse obtained. It then grew in brightness rapidly and was clearly visible at full brightness, still touching the limb, about two seconds later. It was clearly separated from the limb at 14:30:38. The times of these various phases listed in the table are provisional, subject to possible minor revisions after final reduction of the tapes.

The photoelectric light curve of the immersion was secured through the K-line filter and a 0.1-mm. (7.8 seconds of arc) field diaphragm accurately located in the focal plane of the 8-inch photographic refractor. The photocurrent due to the background light of the blue sky, received by an EMI end-on 13-stage photomultiplier, was balanced out by means of mercury batteries and a 10-turn potentiometer. The net deflection from the star (about 0.05 microampere) was recorded with suitable sensitivity. The recording paper unrolled at a speed of about 21 millimeters per second during the main phases of the occultation.

Measures of the tape were made at five-



Three instruments were used for the Peridier Observatory work. At the left is the 12-inch reflector carrying an N-9 camera at its Newtonian focus. At the right, the author observes visually through one 8-inch refractor, while the other is used for obtaining the photoelectric records.



The light curve below was derived from this photoelectric tracing of the immersion of Regulus. The photometer was attached to the 8-inch telescope. A 0.1-millimeter diaphragm and a K-line filter were employed in these observations. Time increases to the right. Harvard Observatory chart.

millimeter intervals, corresponding to 0.24 second of time. They were normalized to make the total amplitude equal to 100 units, as plotted here. The smooth curve is derived from the theory of differential refraction, as developed by Pannekoek in 1903 and by Fabry in 1929. After correction for the fact that the occultation was not central behind Venus as observed in France, the scale height comes out six kilometers. This means that in the region of the upper atmosphere of Venus traversed by Regulus' rays, the density decreases outward tenfold every 14 kilometers. For comparison, the scale height in the lower atmosphere of the earth is about eight kilometers.

The six-kilometer scale height refers to a region of the planet's upper atmosphere some 100 to 150 kilometers above the solid surface. If the "air" of Venus is pure carbon dioxide (molecular weight 44), the mean temperature of this region is about 270° absolute (27° Fahrenheit). Detailed discussion of these observations is now in progress, but final results will not be available before several months have passed.

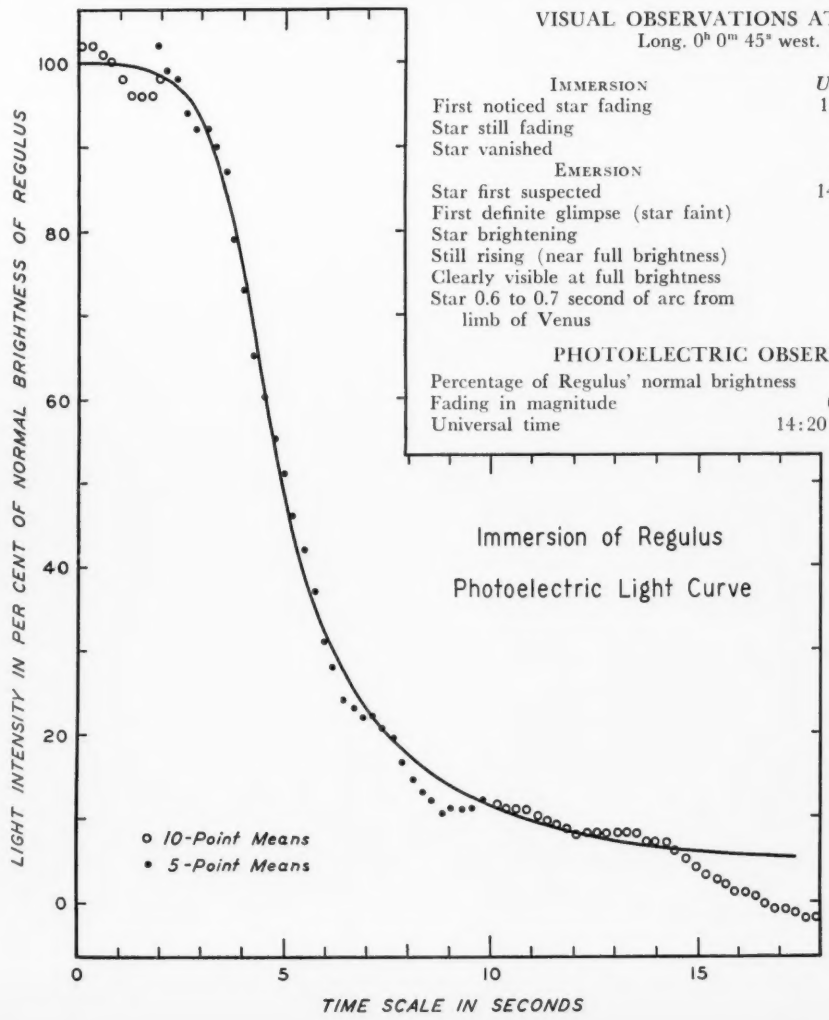
VISUAL OBSERVATIONS AT PERIDIER OBSERVATORY

Long. $0^h\ 0^m\ 45^s$ west. Lat. 43° 46′ 40″ north.

Immersion	*Universal time*	*Change from star's normal brightness*
First noticed star fading	14:20:11.4±	About 1 mag.
Star still fading	12.5	About 1½ mags.
Star vanished	13.6	About 2 mags.
Emersion		
Star first suspected	14:30:26.3 (?)	(Doubtful)
First definite glimpse (star faint)	29.4	About 1½ mags.
Star brightening	30.1	About 1 mag.
Still rising (near full brightness)	30.6	About ½ mag.
Clearly visible at full brightness	31.4	About zero
Star 0.6 to 0.7 second of arc from limb of Venus	38±	(Clearly separated)

PHOTOELECTRIC OBSERVATIONS OF IMMERSION

Percentage of Regulus' normal brightness	90	75	50	25	10	5
Fading in magnitude	0.11	0.31	0.75	1.50	2.50	3.25
Universal time	14:20:08.8	10.3	10.8	12.1	16.7	20.4



In this light curve by the author, the plotted points are running means of measures from the photoelectric tracings at 0.24-second intervals. The continuous curve is theoretical, and corresponds to a scale height of six kilometers for the atmosphere of Venus.

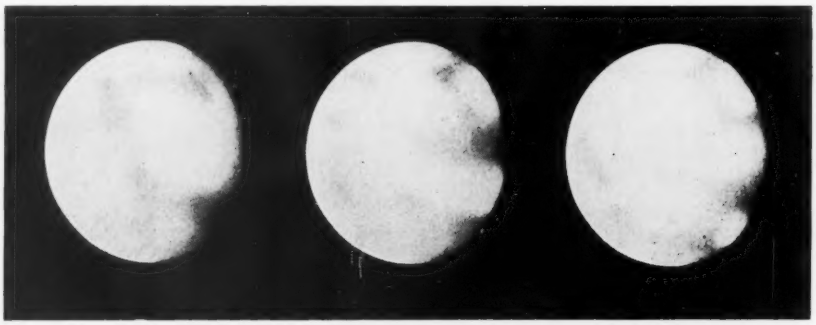
GETTING ACQUAINTED WITH ASTRONOMY

TECHNIQUES OF LUNAR AND PLANETARY OBSERVING — I

THOUGH casual views of the moon or Jupiter in a good telescope can afford great pleasure, these objects offer much more to the enterprising observer. Regular observation trains the eye, and growing familiarity reveals interesting features that went unnoticed at first. Soon the amateur finds that the moon and planets provide many interesting and useful observing projects.

All experts agree that a telescope of excellent optical quality is needed for detailed study of planetary surfaces. For systematic lunar and planetary work, an aperture of four to six inches is probably the minimum required. The advantage of larger aperture is increased resolving power — the ability of the telescope to separate fine detail. Many experienced observers emphasize that 12-inch instruments greatly outperform smaller ones. Very large telescopes, however, can seldom be used to full advantage, because of image blurring from atmospheric turbulence, a difficulty that is less serious with smaller apertures. Whatever size is used, the optics should be of the greatest attainable excellence.

Clyde W. Tombaugh, the discoverer of Pluto, strongly recommends the use of a long-focus Newtonian reflector for lunar and planetary work. Such an instrument is relatively free of most optical aberrations, and is easy to make. A 6-inch mirror of 90 inches focal length does not need to be parabolized; it will perform as well with a spherical surface as with a paraboloidal one.



One of the more difficult subjects in solar system observing is our nearest neighbor planet, Venus. These drawings of its elusive markings were made by L. Rudaux. From "Astronomie," by Rudaux and de Vaucouleurs.

As already indicated above, the beginning observer should realize that his eye needs a great deal of practice before he can see much fine detail. His first views of Mars, for example, may reveal only a tiny ocher disk with a hint of some darker markings. But during repeated observations over an interval of months or years, he will acquire the ability to see much more.

KINDS OF OBSERVATIONS

Drawings of the planets or of lunar surface features are of particular importance, and it is worth while to acquire some skill in making them. The method of pencil sketching explained by R. G. Coutchie on page 450 of the June, 1959, issue can be applied to the planets as well as to the moon. You may also wish to try other art materials, such as lithographic pencils and pastels.

In sketching the moon, it is best to choose for your subject a limited region, for example an individual crater, instead of the entire moon. The drawing is made while at the eyepiece, and, if it is to have any scientific value, should *never* be altered afterward to secure better agreement with the supposed appearance of the subject. Outlines of planetary disks or of lunar craters not too near the limb may be made beforehand to save time at the telescope. With their aid, the observer can depict Jupiter with its proper orientation, or Saturn and the rings tilted by the correct amount.

Series of drawings are valuable. They may be used to record rapid changes in the bands of Jupiter, the night-to-night alteration in the appearance of a lunar crater as the solar illumination changes, or the motions of Martian clouds.

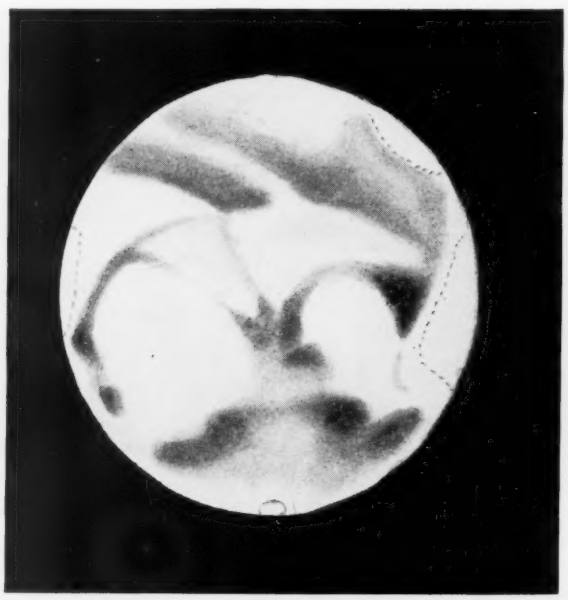
Even if the novice finds that his first drawings show little detail, he should feel satisfied if they have correct proportions and positions of surface markings. A drawing is not a pictorial description

VENUS PASSES REGULUS IN JULY EVENING SKY

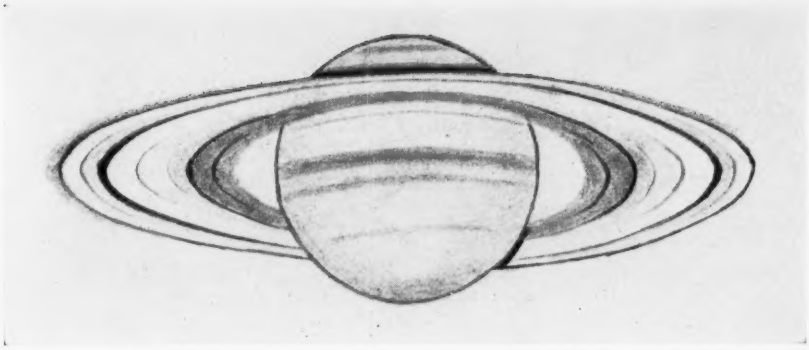
Although few readers were able to see the occultation of Regulus by Venus on July 7th, many noted the nearness of the planet to this 1st-magnitude star.

To show this motion, J. Franklin Campbell of Tulsa, Oklahoma, combined two photographs — one taken at 9:10 p.m., Central standard time, July 6th (upper image), the other on the 7th at 8:30 p.m. CST — superimposing the images of Regulus in the center.

J. Franklin Campbell's composite photo shows Venus passing Regulus in July. North is at the top.



Mars as drawn by Sadao Murayama in Japan on April 27, 1950, at 20:45 Universal time, using an 8-inch telescope and a magnification of 275x. At the center of the disk, the dark Nodus Laocoontis complex is well developed, while three large clouds are to be seen, at the east and west limbs of the planet. South is at the top; at the bottom, the north polar cap is visible.

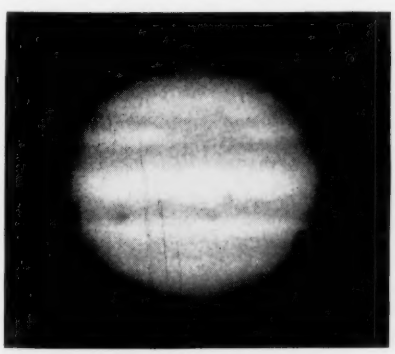


With a 12-inch reflector, Thomas A. Cragg, of Pasadena, California, made this drawing of Saturn on June 5, 1954, at 6:50 UT, using powers up to 336.

only, but might also be measured later to obtain further information.

Observers of Jupiter, Mars, and Saturn should include the timing of **central meridian transits** in their programs. Because Jupiter rotates on its axis in less than 10 hours, its surface features shift rather rapidly across the disk, from right to left as seen in an inverting telescope by a Northern Hemisphere observer. It is possible to tell within a minute or two when a particular marking passes the planet's central meridian (the shortest diameter of Jupiter's elliptical disk). Amateur timings of such transits are particularly sought by the Association of Lunar and Planetary Observers (ALPO) and the British Astronomical Association (BAA), for they are the basic data from which the complex pattern of currents in Jupiter's atmosphere can be charted.

Because conspicuous spots appear rarely on Saturn, the rotation periods of that planet in different latitudes are only imperfectly known. If an amateur is fortunate enough to detect any prominent temporary marking on Saturn, he should make a particular effort to time its central meridian transits. In the case of Mars, transit observations can supply useful information about areographic (Martian) longitudes of surface features, and can be compared with older transits to study the rotation period of the planet.



Jupiter, the largest of the planets, has a complicated banded surface that shows well in this photograph taken at 3:51 UT on March 19, 1956, by H. H. Selby, San Diego, California.

Estimates of the **relative intensities of markings** on the moon's or a planet's surface offer an interesting program. Such estimates are made numerically. The classical visual scale of brightnesses of lunar features (0 = black, 5 = light gray, 8 = white, 10 = dazzling white) may be adapted to the planets. This technique can be used to study variations in the belts of Jupiter and Saturn, or seasonal changes on Mars.

Related to the intensity estimates but simpler to make are those of **conspicuousness.** Thus, the relative conspicuousness of the belts of Jupiter may be obtained by inspection, or by noting the order in which these markings become invisible as the eyepiece is moved out of focus. The problematical changes in visibility of the tiny white spots on the floor of the lunar crater Plato can be profitably studied by keeping systematic records of their relative conspicuousness.

The **colors** of lunar and planetary features are an interesting but rather difficult field of investigation. There are so many causes of false or varying impressions of color that much caution is needed. Only reflectors should be used for color estimates, and the planet should be in a clear, dark sky.

Commercial color filters with known transmission characteristics are very helpful in improving the reliability of estimates of various hues. A yellow cloud in the atmosphere of Mars, for instance, will appear brightest when viewed through a yellow filter, and dimmer through a red or blue one. In the August, 1958, issue, page 517, Charles F. Capen, Jr., described filter techniques for planetary work, and there is an article on lunar colors by V. Axel Firsoff on page 329 of May, 1958.

Many projects are open to the fortunate observer who owns or has access to a **filar micrometer.** He can measure the latitudes of belts on Jupiter and Saturn, the changing sizes of the Martian polar caps, and the size of the illuminated disk of Venus. A very valuable contribution can be made by the amateur who undertakes systematic determinations of heights of lunar features by micrometer measurements of the shadows that they cast upon the surface of the moon.

Photography of the moon and planets is a favorite activity of many amateurs. Pleasing lunar pictures can be obtained with a good 6-inch telescope, but for the planets a 10-inch is perhaps the useful minimum. Reflectors are usually superior to refractors for planetary work, at least in amateur sizes, because they are inherently achromatic. The great value of a photograph is in affording a permanent, objective record, which can be studied at any later time, and on which accurate measurements can be made. For this reason, a careful record should be kept of the date and time at which each photograph is taken, together with data on exposure, photographic materials, and processing.

Nevertheless, most lunar or planetary observing is visual rather than photographic, because much finer detail can be seen in any particular telescope than can be photographed with it.

(To be continued)

EDITOR'S NOTE: This series on lunar and planetary observing is prepared from material originally written by Walter H. Haas for the Astronomical League observing manual (see page 219, March, 1958).

With the 12½-inch Springfield reflector he constructed, Max Collin, Chicago, Illinois, took a series of over 80 lunar photographs to procure a few of this quality. It shows the south and central lunar landscape near last quarter on October 20, 1954.

FLARE STARS

OTTO STRUVE, *National Radio Astronomy Observatory*

ONLY in the neighborhood of the sun is a reasonably complete census of the stars possible. Among these nearby stars, faint red dwarfs are very common and are easily found by their large proper motions. Some of them are especially interesting, because they undergo sudden, short-lived increases in brightness, earning them the designation *flare stars*.

One of the first astronomers to record such a stellar flare was W. J. Luyten, using Steward Observatory photographs taken on December 7, 1948, of the proper-motion star L726-8. They revealed that in the course of a few minutes the star's brightness had risen two or three magnitudes.

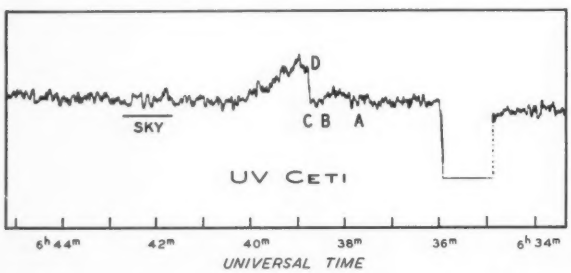
Earlier that year, at Luyten's suggestion, the same star had been observed spectrographically at Mount Wilson Observatory by A. H. Joy and M. L. Humason. The image in the focal plane of the 100-inch telescope was double, showing the star to be a close visual binary. The spectrum was typical of a dwarf *M5* star, but had strong emission lines of hydrogen and ionized calcium. On September 25, 1948, however, bright lines of neutral and ionized helium appeared, and the violet-ultraviolet continuous spectrum was strengthened.

During this exposure, which lasted 144 minutes, Joy and Humason noted an increase in brightness of the system. They stated: "The change in spectrum and brightness was doubtless similar to that observed by Luyten on December 7 of the same year. Luyten suspects that the flare-up was due to line emission originating in the fainter star of the pair; our evidence indicates that the increased brightness arose mostly from the continuous spectrum."

The fainter component of L726-8, now known as the flare star UV Ceti (see page 440, June issue), is the prototype of this class of variables, though previously A. van Maanen had reported two other red dwarfs that undergo transitory increases in brightness. These stars, WX Ursae Majoris and Ross 882, had not received, however, the attention they deserved.

Recently M. Petit compiled a list of 20 objects of the UV Ceti type. In general, the spectra of flare stars are between d*M2* and d*M6*, but at least one is of type *K2*. All normally have emission lines of hydrogen and ionized calcium. During the flare outbursts the hydrogen lines are strengthened, emission lines of neutral and ionized helium and singly ionized iron become visible, and the continuum in the ultraviolet is enhanced. All stars of this type are intrinsically faint, and are located on or near the main sequence of the Hertzsprung-Russell diagram.

Flares occur at irregular intervals and their amplitudes vary greatly in any one star. For instance, the outbursts of UV Ceti are usually about one or two magnitudes; but in September, 1952, two outbursts separated by one week had amplitudes of 3.4 and about six magnitudes. In the former the decline to normal brightness lasted only eight minutes, but in the latter it took nearly two hours.

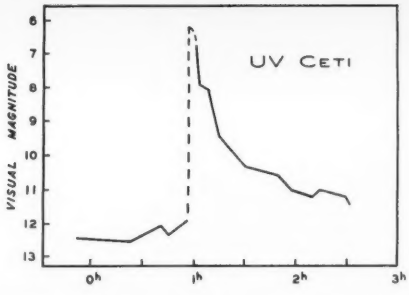


A photometric tracing by P. Roques, Griffith Observatory, on October 29, 1952. A-B is a preliminary surge, the main flare rising from C to D in seven seconds, a 1.6-magnitude change. This and the graph below are from "Publications" of the Astronomical Society of the Pacific.

Although the outbursts are not periodic, each flare star has its own characteristic mean interval, amounting to around 1.5 days for UV Ceti. Between the flares of this star, irregular but continuous variations with a total amplitude smaller than 0.8 magnitude and a mean interval of about 30 minutes have been recorded.

One very interesting property of flares is the great rapidity of the increase in brilliance. During the outbursts of September, 1952, UV Ceti brightened by about a quarter of a magnitude per second! This was 500 times faster than the rise in brightness of Nova Aquilae 1918.

There are some indications that the flare frequency of a particular star changes slowly with time. V. Oskanjan reported at the 1956 Burakan symposium on nonstable stars that no flares of UV Ceti were seen in the observing seasons 1949-50, 1953-54, and 1954-55, but that they were numerous from 1950 to 1953. As Petit has remarked, "the number and the violence of the outbursts . . . are, like the chromospheric eruptions of the sun, subject to a cycle whose duration is a property of each star." Unfortunately, we do not have enough observations to establish flare-star activity cycles resembling the 11-year cycle of the sun's activity, though six or more years has been suggested for UV Ceti.

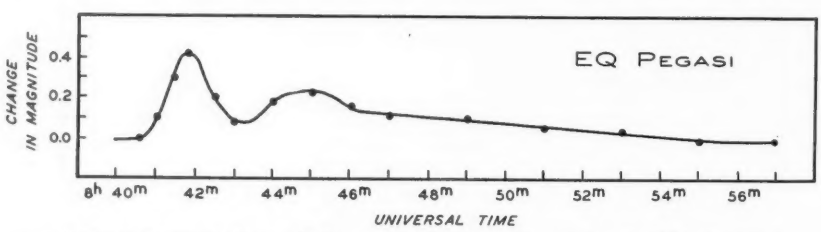


The greatest stellar flare known. At Belgrade Observatory, V. Oskanjan observed this 250-fold increase in light of UV Ceti on September 25, 1952.

Since the outbursts are easily observable, and the stars listed in the table are relatively bright, amateur astronomers could make a very important contribution to astrophysics by providing the large amount of observational data needed to determine these periodicities.

There is very little doubt that stellar flares are physically the same as those of the sun (see page 544, August issue). From the spectra of flare stars, several investigators have estimated the temperatures of the disturbed regions to be of the order of 10,000° absolute. The normal, undisturbed surface of a flare star has a temperature of about 3,000°. With Planck's law of radiation, we can calculate that the visual surface brightnesses of the disturbed and undisturbed regions are in the ratio of 500 to one.

In an ordinary stellar flare, where the brightness rises by about 1.5 magnitudes, the integrated luminosity of the star has only increased by a factor of four. Therefore, T. Walraven concludes that during such a flare the area of the star affected by the disturbance represents only 4/500



P. Roques observed this small flare of EQ Pegasi on September 5, 1954. Its onset was much more gradual than for either of the UV Ceti outbursts shown above.

VARIABLES OF THE UV CETI TYPE LISTED BY MICHEL PETIT

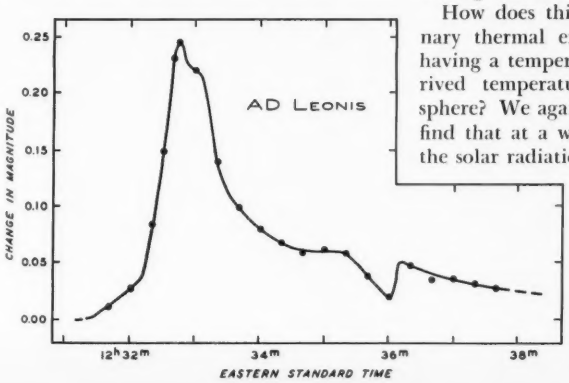
Star Name	*R.A. (1950)* h m	*Dec.* ° ′	*App. Mag. (Photovis.)*	*Change in Mag.*	*Spectrum*	*Abs. Mag. (Visual)*
Wolf 47	0 57.0	+61 50	13.7	?	*M*3e	13.5
UV Ceti	1 34.0	−18 28	12.9	5	*M*5.5e	15.9
V371 Orionis	5 28.6	+ 1 53	11.7	1.8	*M*3e	—
PZ Monocerotis	6 43.2	+ 1 13	9.5	0.7?	*K*2e	—
YZ Canis Minoris	7 39.5	+ 3 48	11.6	1.4	*M*4.5e	12.5
BD +33°1646B	8 02.6	+33 06	11	?	*M*.e	8.6
AD Leonis	10 14.2	+20 22	9.5	0.5	*M*4e	11.1
Wolf 359	10 51.6	+ 7 36	13.5	1	*M*6e	16.5
WX Ursae Majoris	11 00.5	+44 02	14.8	1.8	*M*5.5e	16.0
V645 Centauri	14 22.8	−62 15	11.3	1	*M*5e	15.5
BD +55°1823	16 14.9	+55 32	10.1	0.5	*M*1.5e	8.4
Ross 867	17 16.1	+26 36	13.4	1	*M*5e	13.4
BD +51°2402	18 31.6	+51 39	8.3	?	*K*6e	8.0
V1216 Sagittarii	18 43.6	−23 57	10.5	0.4	*M*4.5e	13.3
W1130	20 02.7	+54 10	12.2	?	*M*3e	11.0
BD −32°16135	20 35.6	−32 47	12.5	?	*M*3e	12.4
DO Cephei	22 24.4	+57 12	11.4	1.5	*M*4.5e	13.3
BD −21°6267B	22 33.3	−21 08	10.2	?	*M*4.5e	—
EV Lacertae	22 42.6	+43 49	10.2	2	*M*4.5e	11.7
EQ Pegasi	23 26.7	+19 23	11.3	0.35	*M*4e	11.1

or about one per cent of the entire surface.

Of course, the temperature of a very violent flare may easily be much higher than 10,000°, and the ratio of surface brightnesses may be greater than 500. Moreover, the integrated luminosity may increase by more than four times. For example, the 1952 increase of six magnitudes in the brightness of UV Ceti corresponded to a factor of 250. But, even for this violent flare, the affected area may have been only a small fraction of the star's surface.

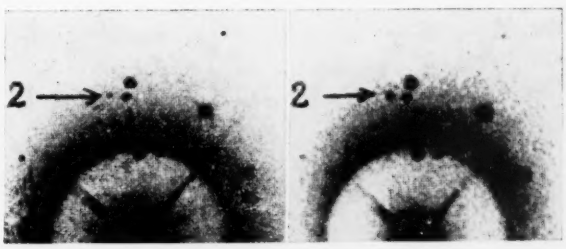
Flares on the sun are often very strong emitters of long-wave radio energy. Hence, with a radio telescope tuned to a particular frequency, we can measure the intensity of the radiation coming from a disturbed solar patch. Knowing this intensity, we can assign a "radiation temperature" to the flare region. This is the temperature that a perfect radiator (black body), similar in dimensions to the disturbed area, would need in order to radiate the same intensity at the frequency at which the measurements were made.

The radiation temperature is usually not the real temperature of a disturbed patch. The two would be the same only if such an area were optically very thick and isothermal — of uniform temperature. In reality, solar flares are optically thin. Nevertheless, the concept of radiation temperature is useful in many applications.



With the 24-inch reflector of McMath-Hulbert Observatory, W. Liller recorded this AD Leonis outburst of February 25-26, 1952. Adapted from "Publications," Astronomical Society of the Pacific.

During the great solar flare eruption of March 8, 1947, the radiation temperature of the disturbance was reported to have been greater than 10^{15} degrees. If we assume that 10^{16} degrees was reached at a frequency of 60 megacycles per second, corresponding to a wave length of five meters, then Planck's radiation law indicates that the total amount of energy received on the earth from this active region was 10^{-12} watt per square meter per cycle per second.



In an Orion nebula survey at Padua Observatory, U. Dall'Olmo discovered two new flare stars in January, 1958. One, indicated by the arrows, increased 3.2 magnitudes within about an hour. From the Italian journal "Coelum."

But the resolving power of our best radio telescopes is too small to observe *only* the disturbed area — what we measure is the *total* energy from the entire sun. Optical observations suggest that during a violent solar flare only about one per cent of the solar disk brightens, while 99 per cent remains quiescent. We conclude that the radiation from the entire quiescent sun at five meters was of the order of 1/100 the value of 10^{-12} observed during the flare, or 10^{-14}.

How does this compare with the ordinary thermal emission of a black body having a temperature of 6,000° — the derived temperature of the sun's photosphere? We again apply Planck's law and find that at a wave length of five meters the solar radiation would be roughly 10^{-18} or 10^{-19} watt per square meter per cycle per second. Thus, even though only one per cent of the solar surface is affected during a flare, the five-meter radio emission is increased to more than 10,000 times that of the photosphere alone.

Suppose now that the flares of UV Ceti resemble the sun's and occupy one per cent of the star's surface. The distance of the sun from us is 1.5×10^8 kilometers, while UV Ceti is 2.6 parsecs or 8×10^{13} kilometers away. Because of the inverse square law for the propagation of radiation, the observed emission from UV Ceti during a violent flare should be about 3×10^{11} times weaker than that of the disturbed sun, or 3×10^{-26} watt per square meter per cycle per second at five meters. According to I. S. Shklovsky this amount of radiation could be detected with existing radio telescopes.

Similar considerations, of course, apply to other nearby flare stars. While we have assumed that stellar flares closely resemble those actually observed on the sun, at times the stellar outbursts are probably far more violent. Thus, there is every reason to search for radio emission among the nearer flare stars.

As far as I know, no such observations have yet been made. The difficulty is that really violent outbursts are rare as well as unpredictable, even in UV Ceti. But perhaps with a larger radio telescope, like the 140-foot paraboloidal antenna now under construction for the National Radio Astronomy Observatory, some of the less intense stellar flares will be recorded.

All of these ideas have been repeatedly advanced by A. Unsöld, whose discussion in the 1955 edition of *Physik der Sternatmosphären* should be read by every radio astronomer. It may even be that he was correct in his attempt to explain a large fraction of the diffuse radio radiation of the Milky Way galaxy in terms of the integrated effect of a very large number of radio stars, many supposedly in the flare stage at any given time.

But his proposal has been severely criticized by Shklovsky, who argues that no matter how we modify the model of stellar distribution of the galaxy, we would require many more radio stars than the total number of all stars, in order to account for the diffuse radio radiation. R. Hanbury Brown believes that most of this radiation may come from peculiar galaxies that are photographically faint. But he considers that some part of the diffuse radiation may actually originate in a large number of real radio stars.

NEWS NOTES

COSMIC ABUNDANCES

During the last few years nuclear physicists have found the semiempirical cosmic abundance table derived by H. E. Suess and H. C. Urey of great value in determining the relative importance of various mechanisms of element formation in the stars. This table is based primarily on analyses of chondritic meteorites, together with Suess' hypothesis that the abundances of elements of odd mass number should lie on a smooth curve.

It has recently become apparent that certain elements are either over- or underabundant in chondritic meteorites for no obvious chemical reason. Not only do the abundances of some nonvolatile elements disagree with similar determinations for the sun, but they differ from predictions of the theory of nucleogenesis in stars. Therefore, A. G. W. Cameron, Atomic Energy of Canada, has revised the Suess-Urey table to make it consistent with his nucleogenesis calculations and, possibly, to throw additional light on abundance discrepancies in meteorites.

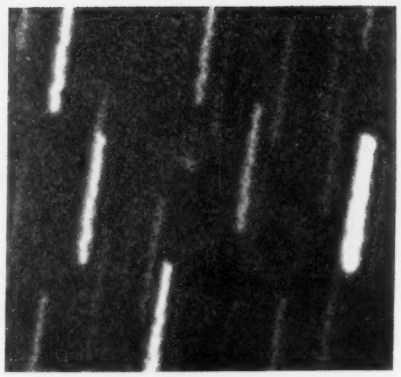
The most substantial changes were made in the region of the rare earths and of lead. The abundance peak for the former section (at mass number 165) now appears broader, more prominent, and more symmetrical than previously, while the lead abundance has been increased to more than 40 times that given by Suess and Urey. In addition, isolated changes were made in a few other cases.

The details of this work appear in the May issue of the *Astrophysical Journal*, from which the table below is reprinted.

COMET GIACOBINI-ZINNER

The comet associated with the great meteor shower of 1933 and 1946 was not observed on its previous return to the sun, in 1953. It is in the sky once more, however, having been rediscovered at the Flagstaff station of the U. S. Naval Observatory by Elizabeth Roemer.

On April 10th she searched unsuccessfully for Giacobini-Zinner; it must have been fainter than the photographic limit of the 40-inch reflector, magnitude 20.5. But on a plate taken May 8th it appeared as a starlike object. In order to keep its faint light concentrated in one spot, Dr. Roemer moved the telescope during the exposure. Thus, the stars in the field are streaks.

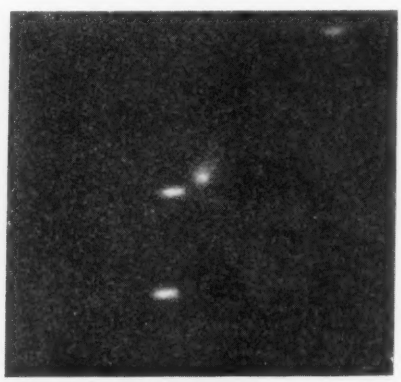


Comet Giacobini-Zinner is the fuzzy object in the center of this recovery plate of May 8th, a one-hour exposure.

By May 28th, the comet was a small diffuse spot, and by June 6th had a central condensation, magnitude about 18.7. It was first detected visually with the 40-inch on July 4th, as a faint, moving, diffuse patch near the limit of visibility.

Comet orbit computers are now improving the necessarily preliminary predictions of the comet's path made by C. Dinwoodie in the 1959 *Handbook* of the British Astronomical Association; these indicate that at the end of October, when Giacobini-Zinner passes perihelion (nearly as far from the sun as is the earth), it will be a 9th- or 10th-magnitude object in the southern evening sky.

A meteor shower like that observed in 1946 cannot be expected, for planetary perturbations have increased considerably the minimum distance between the earth and the comet's orbit. Nevertheless, Peter Millman, in the 1959 *Observer's Handbook* of the Royal Astronomical Society of Canada, suggests that amateurs maintain a vigil on the night of October 9-10, especially between midnight and dawn, as the peak of the Giacobinids is very brief. A strong shower is only a possibility, however, for the earth crosses the comet's orbit about three weeks ahead of the comet itself, whereas in 1946 we were some distance behind it, where the cometary debris is presumably greater.



The comet is the diffuse spot near the star trail in the center of this 15-minute exposure on July 11th, taken without a filter. U. S. Navy photographs.

COMPARISON OF ABUNDANCES OF ELEMENTS IN TABLE OF SUESS AND UREY AND IN PRESENT ADJUSTMENT, BOTH RELATIVE TO Si = 10^6

Element	Suess-Urey	Cameron	Element	Suess-Urey	Cameron
1 H	4.00×10^{10}	2.50×10^{10}	44 Ru	1.49	0.87
2 He	3.08×10^{9}	3.80×10^{9}	45 Rh	0.214	0.15
3 Li	100	100	46 Pd	0.675	0.675
4 Be	20	20	47 Ag	0.26	0.26
5 B	24	24	48 Cd	0.89	0.89
6 C	3.5×10^{6}	9.3×10^{6}	49 In	0.11	0.11
7 N	6.6×10^{6}	2.4×10^{6}	50 Sn	1.33	1.33
8 O	2.15×10^{7}	2.5×10^{7}	51 Sb	0.246	0.227
9 F	1600	1600	52 Te	4.67	2.91
10 Ne	8.6×10^{6}	8.0×10^{5}	53 I	0.80	0.60
11 Na	4.38×10^{4}	4.38×10^{4}	54 Xe	4.0	3.35
12 Mg	9.12×10^{5}	9.12×10^{5}	55 Cs	0.456	0.456
13 Al	9.48×10^{4}	9.48×10^{4}	56 Ba	3.66	3.66
14 Si	1.00×10^{6}	1.00×10^{6}	57 La	2.00	0.50
15 P	1.00×10^{4}	1.00×10^{4}	58 Ce	2.26	0.575
16 S	3.75×10^{5}	3.75×10^{5}	59 Pr	0.40	0.23
17 Cl	8850	2610	60 Nd	1.44	0.874
18 A	1.5×10^{5}	1.5×10^{5}	61 Pm	.....	.....
19 K	3160	3160	62 Sm	0.664	0.238
20 Ca	4.90×10^{4}	4.90×10^{4}	63 Eu	0.187	0.115
21 Sc	28	28	64 Gd	0.684	0.516
22 Ti	2440	1680	65 Tb	0.0956	0.090
23 V	220	220	66 Dy	0.556	0.665
24 Cr	7800	7800	67 Ho	0.118	0.18
25 Mn	6850	6850	68 Er	0.316	0.583
26 Fe	6.00×10^{5}	8.50×10^{4}	69 Tm	0.0318	0.090
27 Co	1800	1800	70 Yb	0.220	0.393
28 Ni	2.74×10^{4}	2.74×10^{4}	71 Lu	0.050	0.0358
29 Cu	212	212	72 Hf	0.438	0.113
30 Zn	486	202	73 Ta	0.065	0.015
31 Ga	11.4	9.05	74 W	0.49	0.105
32 Ge	59.5	25.3	75 Re	0.135	0.054
33 As	4.0	1.70	76 Os	1.00	0.64
34 Se	67.6	18.8	77 Ir	0.821	0.494
35 Br	13.4	3.95	78 Pt	1.625	1.28
36 Kr	51.3	42.0	79 Au	0.145	0.145
37 Rb	6.5	6.50	80 Hg	0.284	0.408
38 Sr	18.9	61.0	81 Tl	0.108	0.31
39 Y	8.9	8.9	82 Pb	0.47	21.7
40 Zr	54.5	14.2	83 Bi	0.144	0.3
41 Nb	1.00	0.81	90 Th	.....	0.027
42 Mo	2.42	2.42	92 U	.....	0.0078
43 Tc	.....	.....			

IN THE CURRENT JOURNALS

MATHEMATICAL INUTILITY AND THE ADVANCE OF SCIENCE, by Carl B. Boyer, *Science*, July 3, 1959. "History indicates on the one hand that the growth of mathematics and the concomitant advance of science are not chiefly the result of utilitarian pressures, but it teaches also that activities of mathematicians which once appeared to be inconsequential have in the end been of far-reaching significance. . . ."

MICA INTERFERENCE FILTERS WITH TRANSMISSION BANDS OF VERY NARROW HALF-WIDTHS, by J. A. Dobrowolski, *Journal* of the Optical Society of America, August, 1959. "This paper deals with the theory, construction, testing, and applications of the mica interference filter. The special features of this filter are the very narrow transmission half-widths attainable and the comparatively high transmissions."

RADIO DETECTION OF SILENT SATELLITES, by Clayt Roberts, Paul Kirchner, and Dave Bray, *QST*, August, 1959. "From the results obtained so far, it appears that the observed signal disturbances are definitely correlated with actual satellite passes, and that each satellite builds and carries along with it a cloud of ionized particles."

RESEARCH IN SPACE, *Science*, July 24, 1959. "In the conviction that the challenge posed by these unprecedented opportunities for scientific study deserves most serious attention, the National Academy of Sciences, through its Space Science Board, seeks to offer encouragement to those who wish to take part in space research programs. This article is addressed primarily to those scientists who may not yet have given serious consideration to the possibility of experimentation in space."

LICK 120-INCH TELESCOPE NEARING COMPLETION

Final preparations are being made to put the world's second largest optical telescope into operation at Lick Observatory, Mt. Hamilton, California. During September, an image tube for the 120-inch reflector will be tested, which will greatly increase the efficiency of the instrument. The 120-inch will join the world's largest telescope, the 200-inch at Palomar Observatory, in exploring distant galaxies and studying stellar evolution.

The Lick telescope was dedicated in special ceremonies on July 16th, after its giant mirror had been aluminized. The installation was begun in 1947, the past six years having been taken up with grinding and finishing the mirror (see SKY AND TELESCOPE, December, 1957, page 69). About 2½ million dollars were budgeted by the State of California for the new instrument and its housing.

OBSERVING THE SATELLITES

SOLAR EFFECTS ON THE UPPER ATMOSPHERE

NEW INSIGHT into the complex effect of the sun on the earth's atmosphere is emerging from correlated observations of many kinds. Hitherto we have supposed that the air was relatively constant in its properties at any given height above 100 or 200 miles. Satellite observations now have shown in the upper atmosphere a surprising variability that is related to solar activity. These results are comparable in importance to the discovery of trapped cosmic radiation in the Van Allen belts, and the two phenomena now seem to be related.

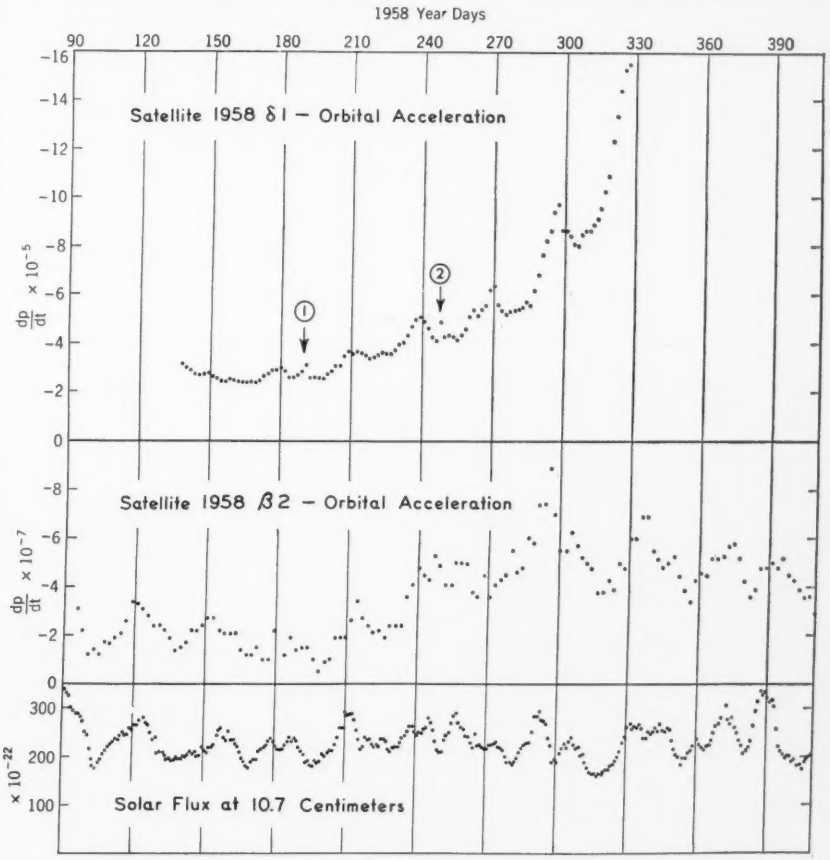
Erratic changes in the orbital period of Sputnik II were detected early in 1958 by Luigi G. Jacchia, Smithsonian Astrophysical Observatory. The initial hypothesis was that the effects came from changes in the satellite's tumbling, but later that year the spherical Vanguard I showed similar changes in orbital period. It was obvious that these came from variations in the atmosphere through which the satellites were traveling.

Meanwhile, Jacchia's graph showing the variable rate of change of orbital period for 1957β1 had been published in SKY AND TELESCOPE (April, 1958, page 278), and thus was noted by the German radio astronomer W. Priester, at Bonn. He called attention to the remarkable similarity of this curve to measurements of 20-centimeter radiation from the sun made during the same time interval.

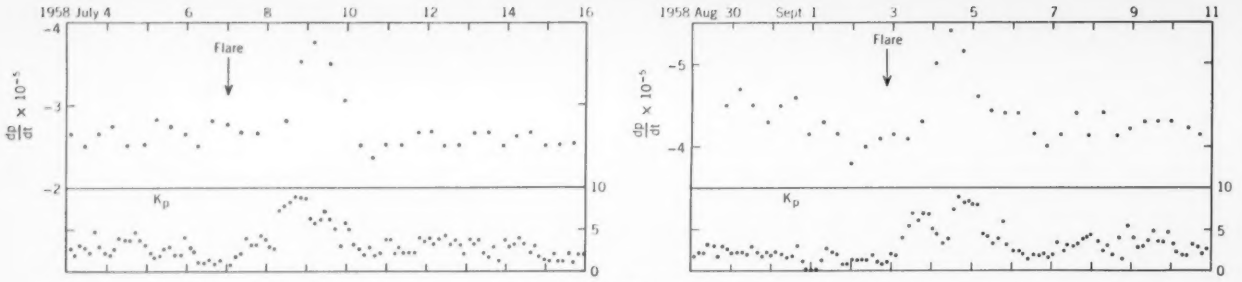
Later, Jacchia showed a correspondence between the changing accelerations (rates of decrease of orbital period) of Vanguard I and Sputnik III. Not only did these vary in unison, but corresponded to oscillations in the solar radiation as measured by 10.7-cm. radio waves received from the sun (March, 1959, issue, page 249).

Recently, the Smithsonian astronomer has reanalyzed the orbital changes of these two satellites, using improved elements, and obtained the average decrease in orbital period for each group of 25 revolutions of the satellites. The curves correlate remarkably well with the 10.7-cm. radiation. Other studies have shown that this radiation is a good index of solar activity. The 27-day periodicity, noticed earlier, stems from the period of the sun's rotation.

There are two unusual points, marked 1 and 2, in the curve for 1958δ1, where



As a satellite loses energy due to atmospheric drag, its period becomes shorter and it moves faster. This chart compares the orbital accelerations (for intervals of 25 revolutions) of Sputnik III and Vanguard I with energy received from the sun at 10.7 centimeters. Smithsonian Astrophysical Observatory graphs.



Orbital accelerations of 1958δ1 for the times marked "1" and "2" in the diagram on the facing page are compared with values of the 3-hour geomagnetic index K_p, which increases at times of magnetic storms.

the drag on the satellite suddenly rose to high levels for very short periods of time. The dates, July 8-9 and September 4, 1958, coincide with the two major geomagnetic disturbances that took place during the satellite's lifetime. These magnetic storms each occurred a day after the appearance of a solar flare of importance 3 (such a flare covers more than 0.1 per cent of the area of the visible solar disk).

In the graphs above, the July and September disturbances in the orbital behavior of 1958δ1 are shown plotted at intervals of five revolutions, and an index of geomagnetic variation is included for comparison.

From the fact that a day elapses between the appearance of a solar flare and the associated geomagnetic storm, it has long been recognized that solar electromagnetic radiation (which comes from the sun in about eight minutes) is not directly responsible for these terrestrial effects. Instead, corpuscles, largely protons, produce the magnetic phenomena. Thus Jacchia concluded from his analyses that the acceleration effect upon 1958δ1 was probably caused by corpuscular radiation. It is evident from the curves that the flare disturbances caused an increase of about 40 per cent in the acceleration, a value more than twice the 27-day effect previously noted.

Although it did not respond to the solar flare as did 1958δ1, the Vanguard sphere showed a 12-fold change in its orbital acceleration between July and October, 1958. The drag on Explorer I (not plotted) doubled during a similar period. Jacchia surmises that the solar storms may have played a major role in this effect also, which leads to the possibility that there is long-term atmospheric storage of corpuscular radiation.

In a later report (*Scientific American*, August, 1959, page 37), Robert Jastrow, National Aeronautics and Space Administration, concludes that there might be a connection between the satellites' orbital behavior and the Van Allen radiation belts. The rocket of Sputnik III traveled in an orbit whose inclination was about 65 degrees to the equator, penetrating the horns of the outer Van Allen radiation belt that reach down toward the earth's surface at high geomagnetic latitudes. The Vanguard sphere, although its perigee of 405 miles is much higher than that of the Sputnik III rocket (128 miles), is inclined at only 34 degrees and does not penetrate the radiation belt. Observations from lunar probes have already shown that the outer belt is fed directly by streams of solar corpuscles. Therefore, the effects on both δ1 and β2 can be brought into agreement with other phenomena.

If the high geomagnetic latitude attained by 1958δ1 was indeed the cause of its quick response to the solar corpuscles (and more observations seem to be needed to confirm this theory), it will be necessary to modify one common assumption: that only near perigee is there appreciable drag upon a satellite. During both solar disturbances the latitude of 1958δ1's perigee was under 35 degrees, nowhere near the auroral region.

Measurements of other kinds also correlate with these findings. High-altitude rocket flights record temperatures over the auroral zones warmer than those at comparable heights in middle and lower latitudes. Jastrow and I. Harris find this temperature difference, amounting to some 900° centigrade at about 100 miles high, to be consistent with the hypothesis of heating of the outer Van Allen belt's horns by energetic solar particles. This heating indirectly leads to increased density and thus, qualitatively at least, can account for the effects noticed by Jacchia.

Another explanation has also been put forward by Jastrow. When a satellite travels through a cloud of charged particles, its metal skin readily picks up electrons from the surroundings. This causes positively charged particles to form a cloud around the fast-moving satellite and effectively increases its cross-section. While Jastrow and C. A. Pearse had previously concluded that this effect would be minor if the voltage difference between the satellite and its surroundings were only about 10 volts, the large energy flux now postulated for certain regions of the atmosphere makes it less certain that electrical drag can be neglected.

Balloon flights have carried instruments to altitudes of about 20 miles, and some of these have shown an increase of about 40 per cent in the number of solar protons emitted in the days following a solar flare of importance 3+. Heavy shielding, such as an inch of lead, may be required to protect occupants of a space vehicle from the energetic protons that might be encountered after a flare.

Lunar Seismology

BEFORE the first astronaut lands on the moon, it is expected that much information concerning the nature of the lunar environment he will encounter will have been telemetered to Earth from unmanned lunar probes. These are now under development, and NASA has recently awarded contracts for several lunar experiments.

At Columbia University's Lamont Observatory and the Seismological Laboratory of California Institute of Technology, seismometers for detecting moonquakes are being devised. Several years will be required for the development of a relatively light, reliable, and rugged instrument capable of detecting seismic activity on the moon.

When seismographs and other instruments can be planted on the moon's surface, we may be able to answer such questions as whether the moon has a core as the earth does; what lunar rocks are like; and how much, if any, radioactive heat is being generated in the moon's interior. In addition, the fall of large meteorites will produce seismic vibrations that may lead to conclusions about the size and velocity of the impacting masses.

Not only is this project dependent on the development of seismometers and telemetering systems but adequate rockets are needed. Probably the Vega will be the first United States vehicle capable of this mission. This rocket will employ, in its two-stage version, a modified Atlas and an altered Vanguard power plant designed to burn during two different portions of the flight. At present, it is planned to use retrorockets to "soft-land" the seismometer on the moon.

Experiments that can be performed from orbiting lunar probes or that can withstand the full force of an unbraked lunar landing will doubtless be tried earlier. Contracts have been awarded to Massachusetts Institute of Technology for measuring the density of electrified gases in the moon's vicinity and to the Naval Research Laboratory for measures of the moon's radioactivity.

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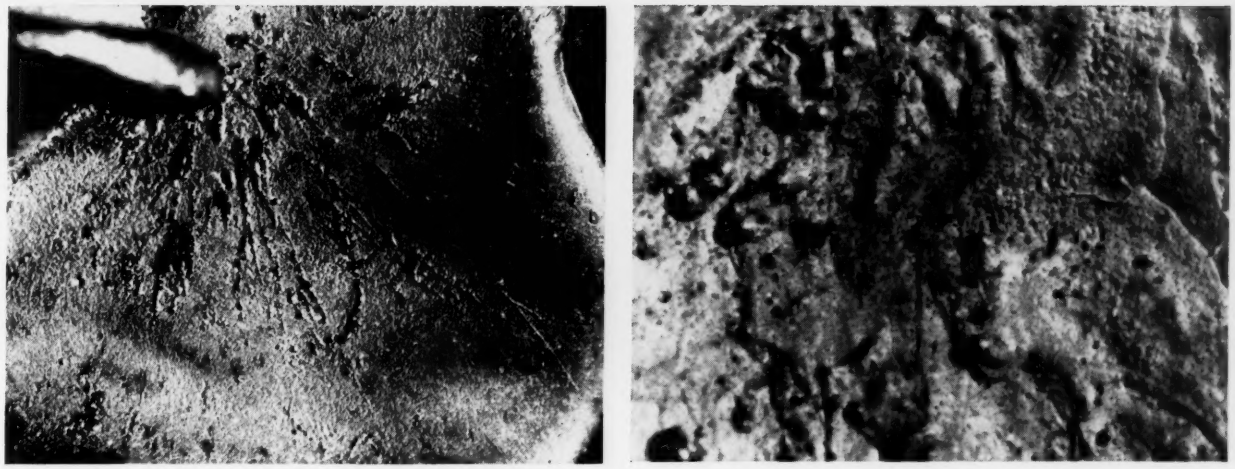

Fig. 1a (left) shows spray drops on the surface of a Sikhote-Alin iron enlarged 12 times. Fig. 1b (right) is a 20x enlargement of individual spherules dispersed on the surface of another Sikhote-Alin meteorite specimen.

Nonterrestrial Dust on the Earth

E. L. KRINOV, *Committee on Meteorites, U. S. S. R. Academy of Sciences*

PROPERTIES of the physical forms of meteorites, in particular of the great Sikhote-Alin fall of February 12, 1947, have been studied by the writer during the past decade. Important data have been obtained on the mechanism by which meteoric bodies disintegrate when they enter the earth's atmosphere at cosmic speeds.

Samples from different meteorite falls clearly bear signs of the phenomenon of *spray*. Solidified droplets are distributed on the meteorite's fusion crust in a way that indicates they were blown from projecting points of the meteoritic body. Fig. 1 shows Sikhote-Alin specimens in which the drops form chains or appear as regular spheres dispersed over the surface. The back surfaces (on the rear side during flight) of some samples have layers of these spheres that give a warty structure to the fusion crust (Fig. 2).

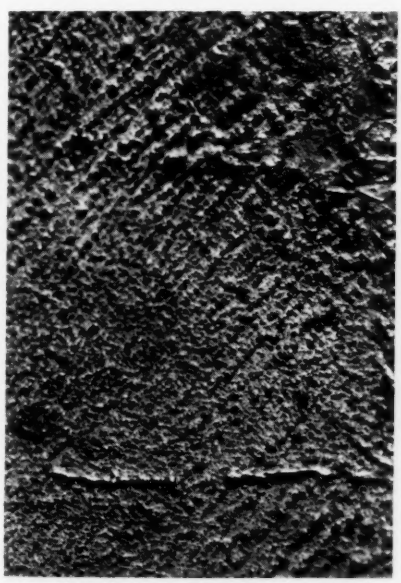

Fig. 2. Fusion crust on the back surface of a Sikhote-Alin specimen, enlargement 17x. Note the warty structure produced by droplets of spray.

This evidence indicates that meteoritic bodies disintegrate by the melting and dispersion of their matter as they move through the atmosphere at high velocities. The minute spray drops immediately cool and solidify into little spherules. Those captured by the meteorite form the spray pattern on its surface described above. The majority of spherical drops, however, make up the meteor train — the typical whitish, long-enduring stripe in the sky that marks the trajectory of very bright and exploding meteors (Fig. 3). Such dust trains are usually of uniform shape throughout their length (until distorted by upper-atmosphere winds), and this uniformity may result from the similarity of the droplet particles in the spray.

These particles in meteor trains disperse into the air, and since meteoritic bodies from interplanetary space frequently invade the earth's atmosphere it is constantly laden with meteoric dust. This gradually settles on the surface of the earth and becomes mixed with the soil. Therefore, the clearly defined spray on Sikhote-Alin specimens and the unusually large dust train (Fig. 4) during the fall prompted the author to predict that solidified little spherules, similar to those on the specimen surfaces, should be found in the area of that fall (SKY AND TELESCOPE, May, 1956, page 300).

First, meteoritic chips were discovered, produced by the splitting of large meteorite masses as they struck the rocky ground. These particles measure from a fraction to several millimeters and, like ordinary chips, have irregular, angular shapes with large deformations. They were usually covered with rust or smears of clay or sand (Fig. 5).

Then, among the meteoritic particles were found a much smaller number of little spherules, indicated by the arrows in Fig. 5. The smallest particle, discovered with a binocular microscope at a magnification of 45 times, is 1/100 millimeter in diameter; the largest is 7/10 millimeter

Fig. 3. A bolide dust train photographed at Chukotka, U. S. S. R., on October 19, 1941, by D. Debabov.

Fig. 4 (left). The fall of the Sikhote-Alin iron meteorite shower on February 12, 1947, as painted by P. I. Medvede. All pictures with this article are courtesy of the Committee on Meteorites, U. S. S. R. Academy of Sciences.

Fig. 5 (right). A 100-times enlargement of meteoritic dust, showing the separate spherules that are meteoric dust (marked by arrows). See the text for the distinction between the two.

(Fig. 6a). These spherules are porous inside.

In addition to these, but much fewer in number, there were found little hollow flask-shaped drops with open necks through which their inner cavities could be seen (Fig. 6b). Also, there are drop-shaped, flattened, and other spheroidal particles.

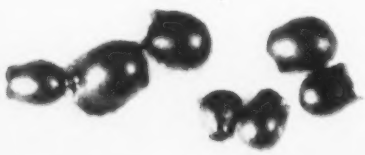

Fig. 6a (left) shows spherules extracted from soil samples taken at the site of the Sikhote-Alin fall. Fig. 6b (above) is an 85-times enlargement of the little hollow flasks also found there.

The little flasks would be formed when the film of melted matter on the meteorite's surface is strained by the pressure of heated gases emitted from the interior. As bits are torn from the surface, spherical cavities are formed with characteristic fringes along their edges (Fig. 7).

All this meteoric dust is of a magnetite composition. This is explained by the oxidation of the drops of melted nickel-iron, due to their high temperature and the oxygen in the atmosphere.

Especially large dust trains are left by the disintegration of iron meteorites. One was seen at the fall of the Boguslavka meteorite in far-eastern Siberia on October 18, 1916. Shortly after, the region was investigated by O. O. Baklund, a geologist, who collected soil samples from the holes of two meteorite masses that weighed 199 and 57 kilograms. More recently the writer has found in these soil samples, in addition to a multitude of pieces of meteorite fusion crust, precisely the same type of spherules as those in the soil at the Sikhote-Alin fall.

In the summer of 1957, A. A. Yavnel studied soil samples from the region of the famous Tunguska meteorite, which fell in central Siberia in 1908. He found meteoric dust in the form of absolutely regular spherules (Fig. 8a), as well as meteoritic dust in minute plates, shavings, and chips (Fig. 8b). Microscopic and spectroscopic analysis established a seven to 10 per cent nickel content for the meteoritic particles.

The writer believes that the smallest particles discovered in 1956 in the area of the Barringer crater in Arizona are meteoritic dust. This work was carried out by an expedition from the Smithsonian Astrophysical Observatory headed by John S. Rinehart (Sky and Telescope, June, 1957, page 366). These particles bear clear signs of oxidation.

Thus, it may be considered established that meteoric bodies produce nonterrestrial dust of two types: *meteoric* and *meteoritic*. The first results from melting of the meteor in the earth's atmosphere; the particles are spheroidal and have an entirely different chemical and mineral composition from the bodies that produce them. This is explained by oxidation of the droplets in the air. Meteoritic dust particles, produced when meteorites strike the ground, have sharp edges and angles and show signs of deformation. However,

Fig. 7. Peculiar to some meteorite specimens are these small spherical cavities or pockmarks in the surface. This piece from the Sikhote-Alin shower of 1947 has been magnified seven times to display the characteristic raised edges of the cavities. The author interprets them as marking the points at which bubbles formed in the fusion crust were torn away from the meteorite during its flight through the atmosphere.

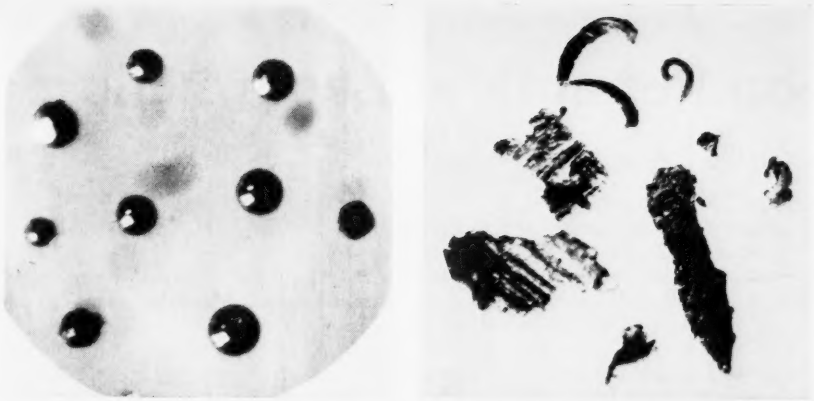

Fig. 8a (left) is of meteoric dust recovered from soil samples collected at the Tunguska meteorite fall, magnified 125 times. Fig. 8b (right) depicts at 37x particles of meteoritic dust from the same place.

they have exactly the same composition and physical properties as the meteorite from which they originate.

Meteoric dust originating from iron meteoric bodies always has a magnetite composition. From stony meteoric bodies, the dust particles probably have the same composition as the fusion crust on stony meteorites.

Dust from such bodies as achondrites of the chladnite type (SKY AND TELESCOPE, June, 1957, page 370), which consist almost entirely of the snow white mineral enstatite and are practically void of inclusions of nickel-iron, is most often white and formed of transparent glass spherules. This has been concluded from such cases as the Staroye Pesyanoye chladnite, which has partially transparent small white veins of glass (Fig. 9). These glass (enstatite) spherules were probably formed when the molten chladnite matter was sprayed. However, spherules of this kind have not been found in connection with the fall of any meteorite.

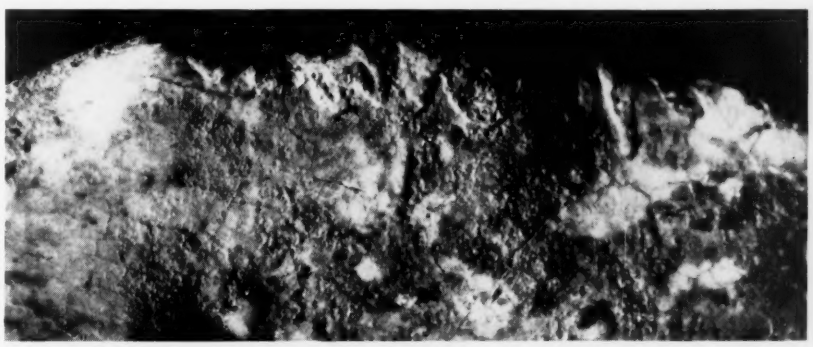

Fig. 9. This stony meteorite (chladnite) from Staroye Pesyanoye shows glassy veins in the edge of its fusion crust.

These particles have been called micrometeorites, but the term cosmic dust seems more appropriate, since they actually are dust particles, and at the surface of the earth would be the same as they were in interplanetary space. Furthermore, it is questionable whether anyone has yet collected cosmic dust. There are only theoretical suppositions, such as given by F. L. Whipple and by V. G. Fessenkov, that such dust actually falls to the earth.

On the other hand, we do find microscopic particles possessing the basic properties of meteorites or, to be more exact, fusion crust, flow marks, and so forth. Distinguished only by the fact that a microscope is required to see them, they are meteorites in the full sense of the word. Some were discovered in the soil of the Sikhote-Alin meteorite shower, sample dimensions and forms being shown in Fig. 10. Since these *micrometeorites* are so small as to approach the size of dust, they may be considered a fourth type of nonterrestrial dust.

During investigations of meteorite falls, samples of the soil should always be taken in order to discover any meteoric or meteoritic dust present there. It must be borne in mind that industrial dust – from factory smokestacks, open-hearth and blast furnaces, locomotives and ships, and other sources – contains a great number of little balls (Fig. 11). These partially resemble in appearance and composition the little spherules of meteoric dust, and have been studied by the writer, by J. Hoppe and H. Zimmerman, and others.

Care must be taken to establish the origin of all dust particles when searching for those from interplanetary space. Industrial dust has been particularly widespread in the United States in the past 10 years. Examination with X-rays is one of the most effective ways of distinguishing terrestrial from nonterrestrial particles. This distinction must be achieved if we are to determine the complete characteristics of nonterrestrial dust: its form, composition, physical properties, daily and annual fluctuation of fall to the earth's surface, and other facts.

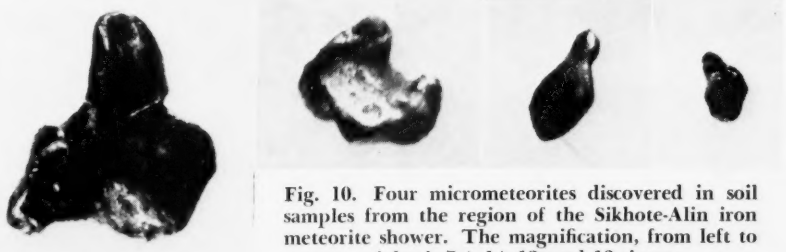

Fig. 10. Four micrometeorites discovered in soil samples from the region of the Sikhote-Alin iron meteorite shower. The magnification, from left to right, is 7.4, 14, 12, and 13 times.

In addition to the two types of dust already mentioned, the writer defines a third type, *cosmic dust*, that which enters the atmosphere directly from interplanetary space. The particles are of such small dimensions that they are delayed in falling from the extreme upper layers of the air, and they are not subject to temperature modifications. Hence, they should eventually come to earth practically unaltered, having the same compositions and physical properties as meteors, lacking the deformations apparent in particles of meteoritic dust.

Fig. 11. This industrial dust (magnified 11 times) simulates many of the characteristics of nonterrestrial dust.

An Experiment on Penumbral Lunar Eclipses

SHIGETSUGU FUJINAMI and YASUHIRO YAMASAKI, *Astronomical Institute, University of Kyoto, Japan*

COLOR PHOTOGRAPHY can be used during this month's penumbral lunar eclipse (see page 650) for a simple experiment to determine the threshold magnitude of the visibility of the penumbra. While the umbra of the earth's shadow is dark and easily observed, the penumbra is very weak, especially in its outer parts, and the moon must be well immersed in it before any effect is discernible.

In the past, several attempts have been made to determine the limit of visibility of penumbral eclipses. Alexander Pogo discussed the problem in *Popular Astronomy* (*45*, 126-129 and 349-352, 1937), and Edward M. Brooks reported observations in SKY AND TELESCOPE (September, 1951, page 270). Pogo defined the limit of visibility as the time when *many* observers first recognized the existence of the penumbral shadow on the moon, whereas Brooks' definition applied to the detection by experienced visual observers.

Our method differs from both Pogo's and Brooks', for they carried out direct visual observations. It is very difficult to determine the limit, since the penumbral shadow is so indistinct and progresses across the moon very slowly. Furthermore, the moon's glare requires careful filter selection, and local weather conditions may affect the results of individual observers. To procure reliable observations from many persons is usually not possible.

Instead, at the eclipse of November 29-30, 1955, we photographed the moon in color while it was passing through the penumbra. Then we made color lantern slides that could be projected at any convenient time and "observed" by any number of persons. Each one was asked to judge whether or not any shadow could be detected on the moon and, if "yes," to indicate its position according to the numbers on a clock face. In all, we have the estimates of 132 observers of a series of 33 lantern slides. Nevertheless, owing to the intrinsic vagueness of this phenomenon, the mean error of our result is rather large.

In the *American Ephemeris* for 1960, page 510, we read, "The magnitude of a lunar eclipse is the fraction of the lunar diameter obscured by the shadow of the Earth at greatest phase, measured along the common diameter." The phase of an eclipse may be defined, in turn, by the formula:

$$P = \frac{\textit{Angular distance from lunar limb to edge of umbra}}{\textit{Moon's angular diameter}}.$$

Thus, when the moon is tangent to the umbral shadow, at what is called first contact in a partial or total lunar eclipse, P is 0.0. It increases as the moon is heavily shadowed, becoming 1.0 when totality begins. In a long total eclipse, where the moon's distance inside the umbra is great, the magnitude or maximum phase can be considerably higher than 1.0.

For a penumbral eclipse, however, the value of P is less than zero, therefore negative. For instance, when the moon's edge is one-third of its diameter away from the umbra (moon well immersed in the penumbra) P is -0.33; when the distance is one-half a lunar diameter, P is -0.5.

Based on his criterion, Pogo found the penumbral threshold phase to be about -0.3, while Brooks for experienced observers obtained about -0.6. Our results are very nearly in agreement with the latter figure, particularly for the 64 experienced amateur and professional astronomers among our observers.

During the penumbral stages of the 1955 eclipse, we took a series of color pictures using an equatorially mounted f/13 Cassegrainian reflector of nearly 4-inch aperture, combined with a Leica camera body and reflex mirror. We observed from the roof of the astronomical institute at the University of Kyoto, with the moon high in the sky and excellent weather (except that it became cloudy during the moon's emergence through the penumbra).

An ultraviolet filter was used, just as for certain terrestrial photography, in front of Sakura 35-mm. color film, and processing was done by the manufacturer in Tokyo. We tested a few frames of each roll on a color chart using daylight. For this slow emulsion (ASA rating 10), the best exposure time on the full moon was about $\frac{1}{8}$ second. But to be sure of the exposure and color rendition, we actually photographed the penumbral darkening in successive exposures of $\frac{1}{2}$, $\frac{1}{8}$, and 1/20 (or 1/25) second, at one-minute intervals.

At the "observing" sessions, we projected each slide twice, the first time at random — without regard to its place in the sequence of the eclipse — then in its proper place with relation to the others. In the first series, the orientation of each slide was also at random, but in the second series it was correct except for a few slides at the beginning and end. The observers were briefed ahead of time and given several examples of the appearance of the penumbra as well as the uneclipsed full moon.

One of the great advantages of the method is in the effective enlargement of the moon's apparent disk, so the groups actually observed as if they were using binoculars of about 7x to 11x.

We classified our observers into *astronomers* and *nonastronomers*. The Astronomical Society of Japan gathered 26 members in Tokyo for a session, and the Astronomical Association of Japan did likewise, for 22 members. At Kyoto, 16 persons on our institute staff participated. The nonastronomers consisted of 23 members of the Society of Scientific Photogra-

The moon during the partial eclipse of November 29-30, 1955. The left-hand picture (q in the table) was taken at eclipse phase −0.52, the other (a) at −0.26. The shadow is in the upper right in each picture. Most observers in the authors' experiment were able to recognize the darkening in the second picture. University of Kyoto photographs.

ESTIMATES BY KYOTO UNIVERSITY ASTRONOMERS

Slide	Observer															Phase
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*	*P*	
b	?	?	?	0	?	0	?	?	0	0	?	0	?	?	?	0	−1.019
x	0	0	0	0	?	0	?	?	0	0	?	?	?	0	?	1	−0.897
i	0	?	?	0	0	0	0	0	0	?	0	0	?	?	?	0	−0.790
k	0	?	0	0	0	?	?	0	0	0	?	0	0	0	0	?	−0.722
ka	0	?	0	0	0	?	?	?	0	0	?	?	?	0	0	1	−0.703
d	0	0	0	0	?	0	0	0	0	?	0	0	0	0	0	0	−0.673
o	?	?	0	?	?	0	?	?	?	?	0	1	1	0	?	?	−0.649
w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−0.624
j	?	?	0	0	0	0	0	0	0	?	0	0	0	?	?	1	−0.609
t	0	?	1	?	1	0	?	1	?	?	0	0	?	1	0	1	−0.590
l_1	1	1	1	1	1	0	1	1	1	?	?	?	1	1	?	1	−0.583
n	0	0	?	?	?	0	?	1	?	0	0	?	?	?	0	1	−0.563
q	1	1	1	1	?	?	1	1	1	?	0	?	?	?	?	1	−0.518
s	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	−0.494
u	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.488
p	1	1	1	1	1	1	1	1	1	1	?	1	1	?	1	1	−0.464
h	1	?	1	?	?	?	?	1	?	?	0	0	1	?	0	1	−0.442
y	1	1	1	1	1	1	1	1	1	1	?	?	1	1	1	1	−0.414
r	1	1	1	1	1	1	1	1	1	1	?	1	1	1	?	1	−0.393
m	1	1	1	1	1	?	1	1	1	1	?	?	1	1	1	1	−0.371
f	1	1	1	1	1	?	1	1	1	1	1	1	1	1	1	1	−0.358
ku	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.340
v	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.324
ko	1	1	1	1	1	1	1	1	1	1	?	1	1	1	1	1	−0.306
g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.294
si	1	1	1	1	1	1	1	1	1	1	?	1	1	1	1	1	−0.284
z	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.273
a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.263
sa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.252
ki	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.204
ke	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.167
c	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.132
e	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	−0.095

Slides were presented to the observers for their estimates in the order, a, b, c, . . . ka, ki, ku, ke, ko, sa, si. The question mark is for uncertain, 0 for no, and 1 for yes.

phy, and 26 from the Educational Association of Natural Science, both groups at Kyoto. Finally, a group of 19 laymen was gathered at Nara. The consistency of the results among such varied groups attests to the soundness of our experiment, and it should be easy for others to follow our example.

The answers were to be *yes* or *no*, but if a person was undecided as to whether or not he saw the penumbra in any one case, he wrote down a question mark. For one picture, these could be equally divided among the *yes* and *no* totals. In 121 cases, however, we treated *yes* answers as *?*, because the shadow's position angle was given as more than 30 degrees from its true value. In the table we present the entire set of observations for the first series by the 16 staff members at the astronomical institute. The second series proved of doubtful statistical value, for memory from one slide to the next affected the judging of penumbral visibility.

Overexposed pictures, for instance *w*, were underestimated, evidently because of low contrast and excessive brightness of the image. Underexposed cases such as *u* were judged relatively high. Exposure *i* was made through a thin cloud, which caused high visibility estimates in that case.

Our analysis of selected slides from the over-all series has been carried out by the least squares method, and is too detailed to present here. It is based on the assumption that the *threshold magnitude* of a penumbral eclipse may be defined as the phase at which 50 per cent of the observers recognize the shadow. For 132 persons, our analysis gives:

Astronomers	-0.61 ± 0.05
Nonastronomers	-0.54 ± 0.07
Average	-0.58 ± 0.06

It might appear that astronomers could recognize the penumbra earlier than nonastronomers, but the average should be regarded as the most probable value since both sets of observations have rather large mean errors (averaging ± 0.06). These figures differ somewhat from those reported in the monthly magazine, *Astronomical Herald*, of the Astronomical Society of Japan (*49*, 198, 1956), because of an improved selection of slides.

NEW WARNER AND SWASEY DIRECTOR APPOINTED

Sidney W. McCuskey has been named chairman of the department of astronomy at Case Institute of Technology in Cleveland, Ohio, as well as director of Warner and Swasey Observatory and the Nassau Astronomical Station. For the present Dr. McCuskey will also remain head of the mathematics department. He has been on the institute's staff since 1930.

J. J. Nassau, director of Warner and Swasey Observatory since 1924, has retired from his administrative posts, but will remain a professor of astronomy and continue his researches. He is president of the Cleveland Astronomical Society.

QUESTIONS . . . FROM THE S+T MAILBAG

Q. What is the human eye's f-ratio?

A. The average adult eye operates at about f/6 in bright light; in subdued daylight, f/3; and in darkness, about f/2.

Q. Do all of the planets move about the sun in the same plane?

A. The planetary orbits lie fairly close to the plane of the earth's orbit (called the plane of the ecliptic). The greatest tilt for any principal planet is 17 degrees — Pluto. A few asteroids have inclinations of more than 30 degrees.

Q. What are the meanings of the terms *sol* and *lux* that appear by some of the stars in the Color Map of the Northern Heavens?

A. Sol refers to the diameter of the star in terms of the sun; hence, 40 sol means that the star has 40 times the diameter of the sun. Lux is the distance of the object in light-years.

Q. Why is there such a spread in the brightness for stars usually called "1st-magnitude"?

A. Almost 2,000 years ago, when the stars were initially sorted out into magnitude classes by Ptolemy, about 20 of the brightest were assigned to the 1st magnitude. When N. Pogson defined the modern magnitude scale, it became necessary to give some of the very brightest stars negative magnitudes. Thus, Sirius is −1.4. "1st magnitude" can, therefore, only be taken to mean that a star is among the 22 now measured to be brighter than visual magnitude +1.50 (see SKY AND TELESCOPE, August, 1957, page 470, for a list of the 50 brightest stars).

Q. When I observe the moon with my telescope, I find the glare very troublesome. How can I reduce it?

A. Three ways to cut glare are: use a filter, either amber-colored or neutral; observe during twilight or by day when the contrast with the background is lower; use high powers to dilute the light intensity.

Q. Is the north celestial pole of Mars marked by a bright star?

A. No. The Martian pole is some distance south of the 3rd-magnitude star Alpha Cephei, close to the border between Cygnus and Cepheus.

Q. When is the next transit of Venus?

A. Venus will next cross the disk of the sun on June 7, 2004, and again eight years later, on June 5, 2012. These transits are both at the descending node of Venus' orbit. The next pair of transits, at the ascending node, will occur on December 10, 2117, and December 8, 2125.

W. E. S.

Amateur Astronomers

A Public Observatory in Connecticut

A PROJECT of the Fairfield County Astronomical Society, in collaboration with the Stamford Museum and Nature Center, is now well under way, as contract negotiations have been completed for a large public observatory to be erected in the area of Stamford, Connecticut.

The main observing instrument will be a 20-inch Cassegrainian-Maksutov designed by John Gregory, with a primary mirror of 26 inches and a 20-inch correcting lens. For photographic work over a flat field five degrees across, it will use a 10-inch secondary mirror, giving the system a 70-inch focal length (f/3.5). For visual observations, the 10-inch mirror will be replaced by one 4½ inches in diameter, the eyepiece power ranging upward from 80, as the effective focal length will be 300 inches. Mr. Gregory, an optical engineer with Barnes Engineering Co., was assisted by Juan Rayces in the design.

As indicated by the architect's sketch, the spacious two-story building will be surmounted by the telescope chamber and 18-foot dome, a massive pier extending downward through the center of the loggia leading to the main entrance. Adjoining the dome is a large roof deck where smaller telescopes can be set up and constellation study carried on.

The lecture room, approximately semicircular in plan, will seat 100 persons, and will have special facilities for demonstrations in astronomy and physics. Other parts of the building will contain a library, darkroom, offices, exhibition space, and a workshop. In the last, telescope making classes are to be held.

The $150,000 observatory is being erected on the grounds of the Stamford Museum, three miles north of the city proper. A gift of $50,000 has been received through the Overbrook Foundation from Mr. and Mrs. Frank Altschul, with added gifts by local citizens and commercial firms. Glass blanks provided by Hayward Scientific Glass Corp. are being processed by the Perkin-Elmer Corp. Richard C. McCurdy is heading a public drive to raise another needed $17,500.

The telescope will have a fork-type mounting. A computer will control the position of the dome slot, to keep it in front of the telescope during long observing periods. Nils B. Mickelson, president of the amateur society, has designed a special computer to permit satellite tracking. The observer will operate a "joystick" while hunting for a satellite. After a very short tracking time, the computer mechanism will have received sufficient data to take over and keep following the satellite without further corrections.

The auxiliary instruments, also designed by Mr. Gregory, are to be an 8-inch f/15 Cassegrainian-Maksutov guiding telescope, a 4-inch f/9 apochromatic spotting scope, and two small 7-power finders.

Completion of the main observatory is scheduled for January, 1960, and of the large telescope within the year. The Fairfield County amateurs will be responsible for the observatory's maintenance.

AMATEUR OBSERVATIONS OF COMETS

AMATEUR ASTRONOMERS who observe comets or who search for them are invited to co-operate with the comets section of the Association of Lunar and Planetary Observers. This section, under the leadership of David D. Meisel, has recently been established as a clearinghouse of cometary information for amateurs, especially among new or inexperienced observers.

For the Western Hemisphere, the official distributor of discovery announcements of new comets is Harvard Observatory. It has now arranged that amateur reports of the findings of new comets should be sent directly to Mr. Meisel, for collation and confirmation. If a discovery is confirmed, he will then notify Harvard.

Any discovery report to Mr. Meisel should contain information as detailed as possible regarding the position, apparent motion, brightness, and appearance of the suspected comet. If the observation is telegraphed, it should be followed by an airmail letter giving all details. Mr. Meisel requests that amateur observers who notify an observatory of such a discovery send him a duplicate report.

A second purpose of the new ALPO section will be the collection of amateur observations of the brightness and appearance of comets. It is planned that, after a comet has faded from view, all data concerning it will be analyzed.

For further information about this program, write David D. Meisel, Comets Section, ALPO, 800 Eighth St., Fairmont, W. Va.

MID-STATES CONVENTION

THE tenth annual meeting of the Mid-States Region of the Astronomical League was held at the University of Tulsa in Oklahoma, June 20-21. The host was the Astronomy Club of Tulsa.

Excellent talks were presented, dealing mainly with meteors, variable stars, and constructing 6-inch Maksutov telescopes. Walter Scott Houston, Manhattan, Kansas, was the banquet speaker, discussing amateur participation in serious scientific research. An award was presented to S. S. Whitehead, Wichita, Kansas, for his work in the region and for helping amateur astronomers.

Officers for the coming year are: J. A. Westphal, Owasso, Oklahoma, chairman; E. L. Clark, Bartlesville, Oklahoma, vice-chairman; Col. Philip Cooley, Norman, Oklahoma, regional representative; and the undersigned, secretary-treasurer.

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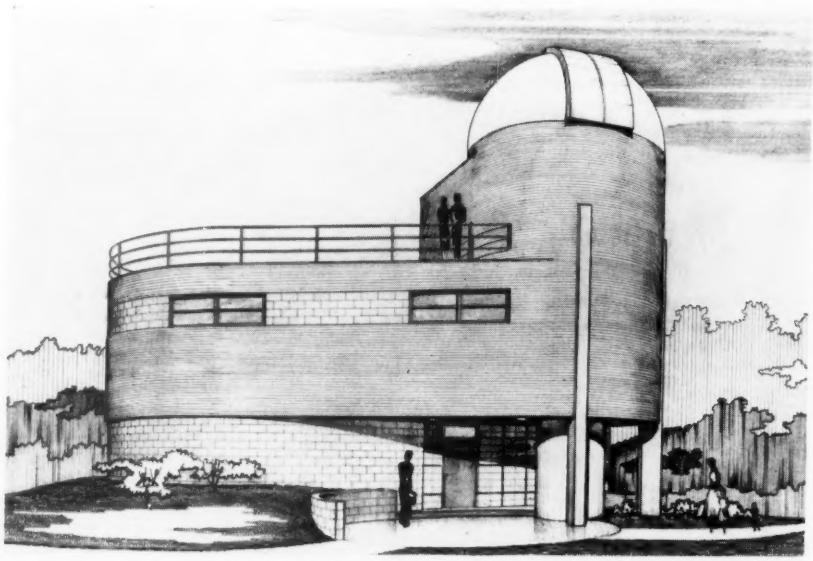
CLEMENT S. BRAININ DIES

A leading figure in popularizing amateur astronomy in New York City, and particularly in the successful growth of the Amateur Astronomers Association, Clement S. Brainin passed away on July 20th at Glen Ridge, New Jersey. He was 72 years old.

Dr. Brainin taught astronomy at Columbia University for many years, retir-



An artist's concept of the $150,000 public observatory to be built at the Stamford Museum and Nature Center in Connecticut.

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TELESCOPE MIRRORS: Made to order. 6", $50.00; 10", $125.00. Merle Welander, Rte. 3, Stillwater, Minn.

FOR SALE: Celestar-4. Nearly new, with all standard eyepieces, electric drive, setting circles, and slow-motion adjustments in both right ascension and declination. Mickey Crist, 2100 Fair Park Blvd., Little Rock, Ark.

INTERESTED in astronomy as a career? *Vocational and Professional Monographs: Astronomy,* by Dr. Freeman D. Miller, describes personal qualifications, scholastic training, and job opportunities. $1.00 postpaid. Send to Box B, *Sky and Telescope,* Harvard Observatory, Cambridge 38, Mass.

TELESCOPES, aluminum tubing, microscope eyepieces. Write Peninsula Scientific, 2421 El Camino Real, Palo Alto, Calif.

DUAL slow-motion mounts. Mirrors, any f-ratio. Refiguring. One excellent 6" reflector. Aluminum castings. John McQuaid, 2003 High St., Logansport, Ind.

FOR SALE: 6" f/20 Cassegrainian telescope, with accessories, $250.00; 30" f/6.3 astro camera, $200.00. For details, write Dennis Moellman, 707 E. McKinley, Belleville, Ill.

TELESCOPES: 3¼" lens. $100.00 value for $40.00, $25.00 value for $15.00. $30.00 equatorial mount for $15.00. Two rebuilt gun sights, $15.00 each. F. Myers, 11105 W. Potter Rd., Wauwautosa, Wis.

8" SETTING CIRCLES: $1.00 a set. Locate faint and hard-to-find objects quickly. Finely divided, center marked. Printed on heavy plastic-coated paper. Full instructions included. Write for free catalogue, everything for the telescope maker. ANRA Manufacturing Engineers, 7431 Canoga Ave., Canoga Park, Calif.

COMPLETE Model 140 Unitron. Purchased new this May. Extra accessories: Unihex, sun screen, 5-mm. eyepiece, others. Cost $322.00, will take $200.00. Ben Pingenot, Box 658, Eagle Pass, Tex.

FOR SALE: New 4" Dynascope, complete with equatorial mount, two eyepieces, Vernonscope Barlow, $59.00. Dave Snow, Brooktondale, N. Y.

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CLOSEOUT SALE: "Satellite Pathfinder," an ingenious device designed at the American Museum-Hayden Planetarium to help predict Northern Hemisphere passages of artificial satellites. $1.60 postpaid. Send to Box C, *Sky and Telescope,* Harvard Observatory, Cambridge 38, Mass.

FOR SALE: 4¼" equatorial reflector, hardly used. Write for details and photo. D. MacLauren, 34 S. Broadway, Pitman, N. J.

6" FECKER Celestar, mint condition, illness, sell ½ price, $300.00. James McBride, 2145 Oak Hill, Youngstown 7, Ohio.

UNITRON 2.4" equatorial refractor, 1957 model. Sacrifice for college expenses. Prefer buyer in immediate area. David Ruff, West Fargo, N. D.

SUPERB 8" refractor, f/19, for visual or photographic work. Best offer over $5,500.00. Rex Bohannon, 3415 Santa Carlotta St., La Crescenta, Calif.

TELESCOPE MAKERS: Limited quantity of Allyn J. Thompson's *Making Your Own Telescope* for only $1.50 each, postpaid. These 75 copies have damaged covers, but the inside pages are in good condition. First come, first served. Sky Publishing Corp., Harvard Observatory, Cambridge 38, Mass.

ing from this position in 1939 when he founded an electrical equipment firm in Mt. Vernon, New York. He had graduated from Columbia in 1908, joining its faculty while studying for his doctorate, which he received in 1917.

He was the third president of the AAA, serving capably in this capacity for many years. Dr. Brainin was also a member of this magazine's editorial advisory board.

NORTHEAST CONVENTION

Highlight of the Northeast regional convention of the Astronomical League, October 2-4, will be witnessing the total eclipse of the sun on Friday morning, October 2nd, from Lynn Beach, Massachusetts. That afternoon there will be an eclipse session at the Boston Museum of Science, during which photographs and slides taken at sunrise will be exhibited.

Following this program, delegates will visit the museum's Charles Hayden Planetarium for demonstrations of its Korkosz projector. Saturday will be devoted to talks on observing and instrumentation, as well as a junior session, the day ending with the convention banquet. A field trip to inspect the 60-foot radio telescope at Harvard Observatory's Agassiz Station is scheduled for Sunday afternoon.

Hosts for the convention are the Amateur Telescope Makers of Boston and the Bond Astronomical Club. Further information is available from: Eclipse Committee, ATM's of Boston, Harvard Observatory, Cambridge 38, Mass.

ROBERT H. DELLAR

The National Capital Astronomers, of Washington, D. C., lost one of its most highly esteemed members on July 26th, with the passing of Robert H. Dellar. He was the leader of an NCA Moonwatch team, which was set up at his home in Springfield, Virginia. His suggestions for satellite-tracking techniques and instrumentation were helpful in Moonwatch planning.

ERIE, PENNSYLVANIA

Last February an astronomy club known as M31 was organized by 10 amateurs in Erie, Pennsylvania. Meetings are held every three weeks at the home of the secretary, R. Stuart Cadwallader, 916 Kahkwa Ave., from whom more details may be secured.

STOUGHTON, WISCONSIN

Six adult and 15 junior members comprise the Stoughton Astronomy Society. The chairman is Hugh Jensen, 113 S. Franklin St., Stoughton, Wis.

THIS MONTH'S MEETINGS

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. September 12, Dr. F. J. Heyden, S. J., Georgetown University Observatory, "Measuring the Sun's Energy with a Solar Eclipse."

A word from Ward...

EXACTLY HOW BIG IS BIG?

There was the person who once asked Abe Lincoln how long a man's legs ought to be — and Old Abe, thinking a while, allowed as how a man's legs ought to be long enough to reach the ground.

Size — for the sake of size alone — isn't important. It's what you do with the size after you stretch into it that counts. I've seen an ant lug a pebble fifteen times its own weight. Compared to this creature, I'm a first-rate Boulder Dam. But on the basis of comparative strength that pesky ant has me licked to a frazzle.

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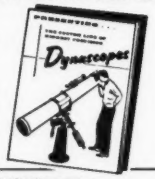

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"A friend of mine has a 6-inch telescope without electric drive, for which he paid over $500. He agrees that my new DYNASCOPE not only outperforms it, but is a much better-looking and better-built instrument." **J.L. — New York**

"Congratulations on the excellence of your workmanship. The optics are truly amazing. I never expected such wonderful performance."
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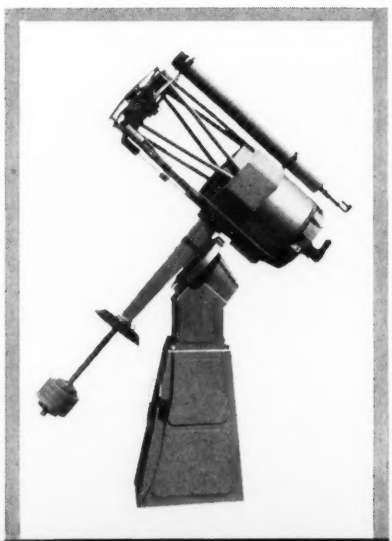
With the Baker photographic corrector the telescope performs its second job with unusual versatility. The corrector permits photography of a seven degree field—a picture equal in width to 14 full moon photos laid side-by-side!

BYU's telescope, now in operation at Provo, Utah, is an example of the precision craftsmanship and exacting specifications which have built Tinsley's reputation as the leader in custom optical instrumentation.



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OBSERVER'S PAGE

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Observing and Reporting Shadow Bands

AT AN ECLIPSE of the sun, about two minutes before the moon's disk shuts out the sun's light along the path of totality, narrow bands of "shadow," varying from about ½ to two inches in width and separated by about two to 10 inches are seen where favorable conditions of contrast exist.

These shadow bands move in various directions as seen by observers at different sites, and there does not at first appear to be any systematic pattern in their behavior. The phenomenon is repeated for about two minutes after totality, with changes of widths, orientations, and directions of motion.

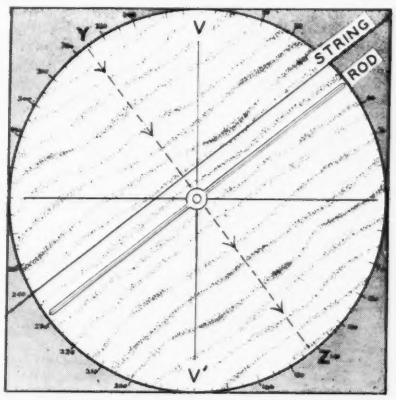
But observers have seen the bands on all sorts of surfaces, some horizontal, some vertical, and some oblique. To compare their results is a laborious task. Of 60 or more reports from past eclipses that have been examined by the writer, only two or three presented all the required information.

Admittedly, it is difficult to report shadow bands, but by establishing a standard method and using uniform techniques, consistent results should be obtained, perhaps at the coming October 2nd eclipse. Of course, in view of the low altitude of the sun, atmospheric conditions may preclude the occurrence of shadow bands.

Prospective shadow-band observers can build an easily portable wooden framework (about five feet square) to be erected at the observing site. It should have diagonal braces, and in the center, where they join, a central rod protruding outward from the face of the screen. Stretch white cloth or canvas to cover the framework and insert the central rod, allowing it to project a foot or more. In the last few minutes before totality, orient the rod so it casts no shadow, which will place the screen surface at right angles to the axis of the moon's shadow cone.

On the screen mark out a circle five feet in diameter, or of whatever size will fill the area. Label the circle periphery in degrees. An orienting rod may be attached to revolve around the protruding rod, or string can be stretched from one side to the other to parallel the shadow bands when they appear. Hooks can be installed along the edges of the framework for attachment of the string. A line down the center of the screen, **VV'**, should be set vertical with the aid of a plumb bob. If strings are used, prepare at least 10 of them with numbered tags for identification when recording the observations after the eclipse is over.

Three persons make a good observing team. When the bands first appear, one observer stretches the first string parallel to their length, fastening it with a thumbtack or push-pin to mark their orientation. Repeat this operation every 30 seconds if changes take place, but if there are none that fact should be reported also. The changes that occur will, in all probability, be repeated in reverse sequence after totality. Orientation angles will be measured and designated with 0° at the top of the circle and 90° to the right (clockwise). All measurements are made facing the projection screen with the observer's back to the sun.



This drawing by Edgar M. Paulton shows the screen suggested for observations of eclipse shadow bands.

The first observer must also note the direction of motion of the bands, using a 12-hour clock-dial system to avoid confusion with orientation angles. Thus, a direction of motion might be 10:45-4:45; bands moving opposite to this direction would be 4:45-10:45. The direction of motion may or may not be perpendicular to the orientation. Do not allow one reading to influence the other.

As soon as the first observer has finished, he should step away from the screen to allow an unobstructed view for the other two. The second observer, with a stop watch in hand, alerts the other with a "one-two-three-now" announcement. Starting the stop watch at the word "now," he concentrates his sight on one of the dark bands at the edge of the projection circle (**Y** in the diagram) and follows it across the diameter to the opposite side (**Z**). When the band reaches **Z** he calls "now" again, simultaneously stopping the watch and thus determining the time for the band to travel the width of the circle.

From the first "now" to the second, the third observer counts the number of bands that travel across the perimeter of the circle at **Z**, to determine the number of bands in five feet, or in the width of the circle. This procedure should be repeated at 30-second intervals.

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do, rehearsals are required to develop teamwork. More detailed instructions and complete report forms may be obtained by writing to: Shadow Band Recorder, Amateur Astronomers Association, 201 W. 79th St., New York 24, N. Y. Results and statistics obtained on this program will be sent to all contributing observers.

EDGAR M. PAULTON
27 Joyce Rd.
Hartsdale, N. Y.

OBSERVATIONS WANTED OF MOON'S SHADOW

OBSERVERS in all parts of the northeastern United States are asked to participate in an observing program being conducted by the eclipse committee of the Amateur Astronomers Association in New York City. Its purpose is to determine the characteristics of the moon's shadow when it strikes the atmosphere on the morning of the eclipse in October.

As described on page 566 of the August issue, there is great variation in the appearance of the shadow in the sky, depending on the location of the observer with respect to the central line. For this reason, we have divided observing locations into four areas, all equally important in this program but requiring somewhat different sets of observations. A. Within the path of totality. B. A bordering region extending 100 miles or more to the north, northeast, and northwest of the path. C. A similar region to the south and southwest of the path. D. A belt some 100 miles wide running westward from central Massachusetts through Albany, Buffalo, and into Canada, being an extension of the central line.

The eclipse will be seen as total only in A, but D observers will have the sun located a relatively short distance below their horizons at mid-totality. And even outside B and C, early risers should look for the moon's shadow in the sky, as one of our purposes is to determine how far from the path of totality the shadow can be seen. On July 9, 1945, one observer saw it from a distance of 300 miles.

This type of study has been attempted only once before, in 1945 by Prof. John Q. Stewart, of Princeton University (SKY AND TELESCOPE, May, 1945, page 3). It is with his advice that we are planning to repeat his program, in order to verify and extend his results. We have developed easy-to-fill data sheets — revisions of one Professor Stewart used — which will be supplied upon request.

For all observers of the eclipse, and especially for those who cannot journey to the path of totality, this project presents an opportunity to contribute useful scientific observations. I shall be pleased to send the proper questionnaire to everyone who writes me.

WILLIAM H. GLENN
AAA Eclipse Committee
201 W. 79th St.
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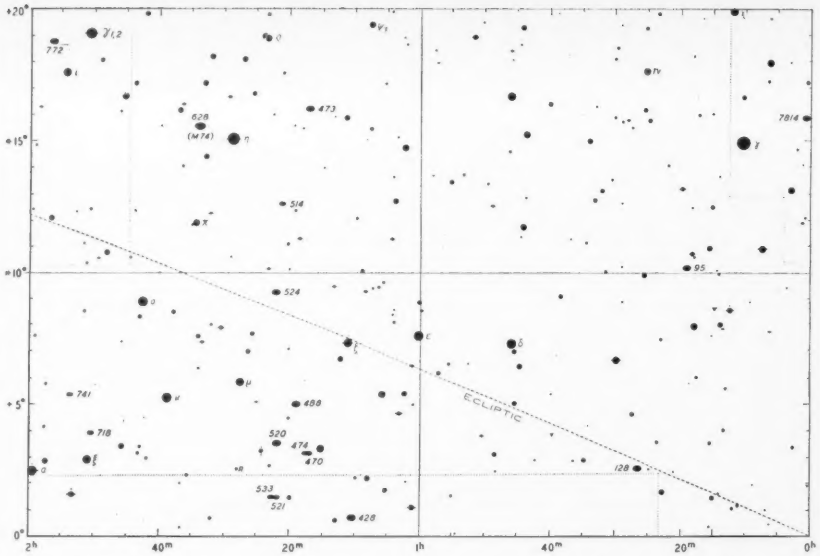

The sky from right ascension 0h to 2h, and from declination 0° to +20°, with 17 galaxies indicated. Adapted from the Skalnate Pleso "Atlas of the Heavens."

DEEP-SKY WONDERS

EAST AND SOUTH of the Great Square of Pegasus stretches a dim and usually neglected region which belongs mostly to Pisces. Few ever probe this area, for here are found no planetaries, clusters, or nebulosities. Yet the lack of local galactic obscuration enables us to see many faint galaxies far beyond our local system.

NGC	R.A. (1950) h m	Dec. ° ′	Phg. Mag.	Vis. Mag.	Size ′ × ′	Type	Herschel No.	Notes
7814	0 00.7	+15 51	12.4	—	3.0 × 0.8	Sa	II 240	Easy
95	0 19.6	10 12	13.1	—	—	—	II 257	Difficult
128	0 26.7	2 33	12.9	—	2.5 × 0.4	S	II 854	Difficult
428	1 10.4	0 43	11.9	—	4.0 × 2.2	S	II 622	Seems brighter
470	1 17.1	3 09	12.4	12.5	1.6 × 1.0	Sc	III 250	Fairly easy
473	1 17.5	16 14	13.1	—	—	—	III 206	Not seen in 1957
474	1 17.5	3 10	12.6	11.9	0.4 × 0.4	E	III 251	Faint blur
488	1 19.1	5 00	11.8	11.1	3.0 × 3.0	Sa	III 252	Seems fainter
514	1 21.3	12 39	12.4	—	2.0 × 2.0	S	II 252	
520	1 22.0	3 32	12.4	—	3.0 × 0.7	I	III 253	Brighter than NGC 514
521	1 22.0	1 28	13.0	—	—	—	II 461	Not seen
524	1 22.1	9 16	12.0	11.1	2.6 × 2.6	Ep	I 151	Easy
533	1 22.9	1 30	13.0	—	—	—	II 462	Not located
628	1 34.0	15 32	11.2	10.2	8.0 × 8.0	Sc	—	M74
718	1 50.7	3 57	12.7	—	0.5 × 0.4	—	II 270	Fairly easy
741	1 53.8	5 23	13.0	—	—	—	II 271	Faint
772	1 56.6	18 46	12.0	10.9	5.0 × 3.0	Sb	I 112	Easy

Successive columns of this table list the galaxy's number in Dreyer's *New General Catalogue;* right ascension and declination in 1950 co-ordinates; photographic magnitude; visual magnitude; size; Hubble type; number assigned by William Herschel; and notes by the author.

In the region between right ascension 0h and 2h, and declination 0° to +20°, we list 17 of these outposts of perception. Only one, M74, is bright enough to be a Messier object. The others are mostly Herschel classes II and III, meaning that they are faint in medium-sized telescopes, but visible in reflectors of 10-inch aperture or larger.

Observers with poor skies or small telescopes, who cannot pick up these objects, should seek out M31, nearby in Andromeda, and M33 in Triangulum, galaxies that still inspire experienced observers.

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— Luis L. Osuna, Avenal, California

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Then nothing happened for the next eleven months. Absolutely nothing. Finally, in May he sent the instrument to us, and at once we located the trouble — the prism was quite askew in its clamp, which made the whole instrument seem badly out of line. We wrote him about it, which elicited the letter from which we are quoting.

"It is surprising how much I miss the Questar, which is one reason I delayed so long in sending it back. I have a larger telescope, but the inconvenience of setting it up makes Questar the one I use most of the time."

We think this is an interesting comment, but we find Mr. Osuna's actions even more interesting than his words. For here is a man who apparently has become so fond of using an instrument, night after night, that he postpones sending it back for almost a year. He knows that something is a little off, but he hates to do without his favorite telescope long enough to have it fixed.

We think this is wonderful consumer acceptance. And we also think we understand the situation a little. Do we not all get attached to a certain coat, or shirt, or suit of clothes, or pair of shoes, and then persist in wearing this most comfortable thing as much as possible? This is what happens to many Questar owners. They fall in love with the instrument, and they use it all the time.

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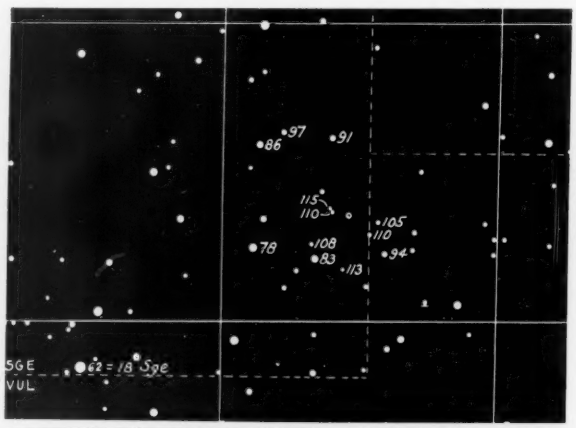
The Peculiar Variable Star V Sagittae

ONE of the most intriguing of variable stars is V Sagittae. Though it varies in a cycle of some 530 days, during which it changes from magnitude about 10 to 13, it also has a superposed shorter variation of a magnitude or so in eight to 18 days. In addition, sudden changes often take place within a few minutes, while on other nights it may remain nearly constant for some time.

This star is located in the northeast corner of Sagitta, at right ascension 20^h 18^m.0, declination +20° 57′ (1950 coordinates). Lydia Petrovna Ceraski, working at Moscow, discovered its variability in 1902. Its spectrum is peculiar, and the prototype star of its variation is Z Andromedae. V Sagittae can become as bright as magnitude 9.5 at maximum, while it has been as faint as 13.9.

The American Association of Variable Star Observers is interested in obtaining more observations of V Sagittae, and has set up the following schedule of times during which observers should watch. All reports will be welcome.

September 1, 4:00 — 4:15 Universal time; 1, 5:00 — 5:15; 11, 21:00 — 21:15; 12, 4:30 — 4:45; 12, 21:30 — 21:45; 17, 21:00 — 21:15; 18, 4:30 — 4:45; 25, 21:00 — 21:15; 26, 3:45 — 4:00; 26, 4:30 — 4:45; 26, 21:00 — 21:15; 27, 3:30 — 3:45; 27, 4:00 — 4:15; 27, 20:30 — 20:45; 28, 3:30 — 3:45.



The field of V Sagittae, from an AAVSO "b" chart. The variable is marked by the open circle to the right of center. Visual magnitudes of comparison stars are given without decimals. South is at the top, east to the right. The top horizontal line is declination +20°, the bottom +21°. The left-hand vertical line is right ascension 20^h 12^m, the right-hand 20^h 16^m. These are 1855 co-ordinates. Each millimeter is 82 seconds of arc.

Diffraction theory as applied to the observation of extended surfaces

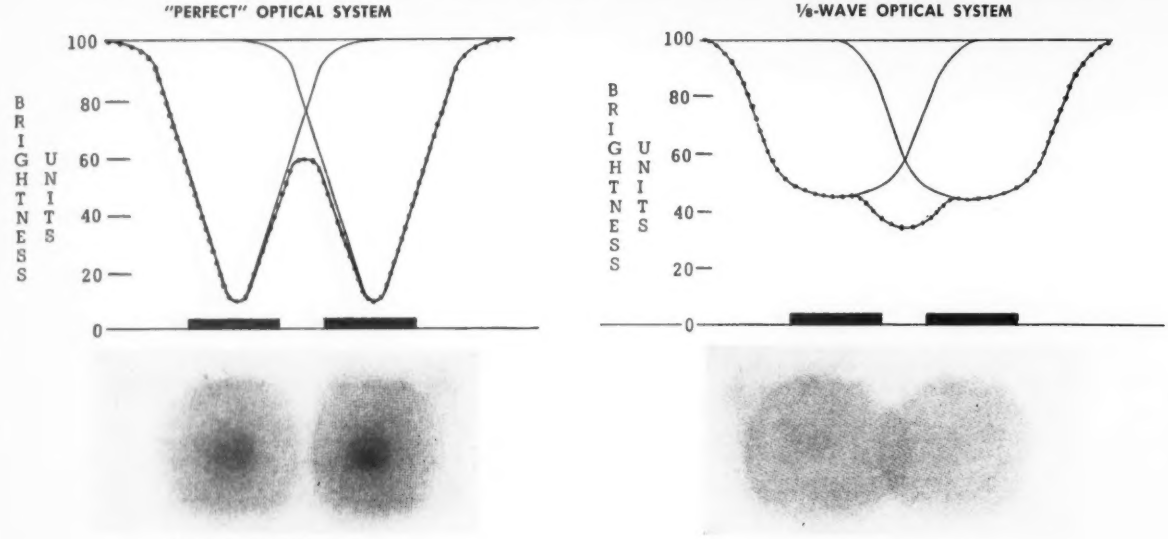


Image as seen at the eyepiece. *Image as seen at the eyepiece.*

The diagrams above illustrate graphically the *practical* utility of 1/20-wave optics in a reflecting telescope. The black horizontal bars represent a cross-section of two tiny dark markings on a planetary surface, each one second of arc in diameter, separated by half a second of arc. The scale is correct for a 5.5-inch telescope. The diffraction curves for the markings are shown, as well as the resultant or combined brightness curves (knotted lines).

If you are interested in having the finest possible optics for your telescope, please write for a fuller discussion of the above, as well as many practical suggestions for obtaining maximum performance from your instrument, in our free booklet, *The Reflecting Telescope.*

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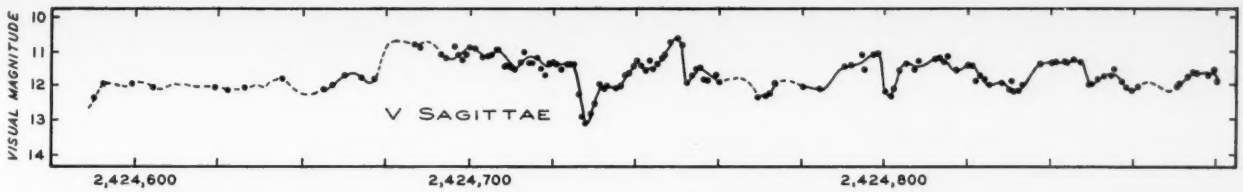

Variations in the brightness of V Sagittae, plotted by Luigi G. Jacchia from his visual observations and those of P. M. Ryves. This section of the extensive curve published in the "Memoirs" of the Italian Astronomical Society (1934) extends from March to December, 1926. From his analysis of data for this star from 1926 through 1931, Dr. Jacchia found a period of about eight days superimposed on a 530-day one. The spectrum of V Sagittae resembles that of a nova many years after its outburst.

If the star remains constant, it is sufficient to report the times of beginning and ending and the magnitude, for example: September 1, UT 4:00 – 4:15, constant 11.5. Should the star be changing, make observations as rapidly as possible, and give an accurate time for each observation. If it starts to vary near the end of the requested period, it would be of great value to follow it as long as possible, or until it becomes constant once more.

Charts showing comparison stars for this variable may be obtained from Richard W. Hamilton, 15 Fox Hill Lane, Darien, Conn. Both "b" and "d" charts are available, at 14 cents each.

MRS. MARGARET W. MAYALL
American Association
of Variable Star Observers
4 Brattle St.
Cambridge 38, Mass.

SUNSPOT NUMBERS

The following American sunspot numbers for June have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

June 1, 130; **2,** 137; **3,** 148; **4,** 162; **5,** 146; **6,** 148; **7,** 146; **8,** 156; **9,** 169; **10,** 152; **11,** 168; **12,** 164; **13,** 163; **14,** 164; **15,** 152; **16,** 162; **17,** 137; **18,** 168; **19,** 111; **20,** 115; **21,** 138; **22,** 129; **23,** 181; **24,** 163; **25,** 169; **26,** 148; **27,** 169; **28,** 156; **29,** 135; **30,** 134. Mean for June, 150.7.

Below are mean relative sunspot numbers for July by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

July 1, 142; **2,** 118; **3,** 138; **4,** 158; **5,** 136; **6,** 127; **7,** 110; **8,** 131; **9,** 129; **10,** 127; **11,** 133; **12,** 135; **13,** 160; **14,** 180; **15,** 185; **16,** 190; **17,** 193; **18,** 195; **19,** 184; **20,** 160; **21,** 132; **22,** 94; **23,** 113; **24,** 105; **25,** 118; **26,** 134; **27,** 156; **28,** 181; **29,** 182; **30,** 193; **31,** 190. Mean for July, 149.3.

JULY AURORAS

Four auroras during July have been reported to this magazine. The first, on the evening of July 4th, was seen by Herbert A. Luft in the Catskill Mountains. On the evening of the 17th, West Coast amateurs witnessed a fine display, descriptions being sent by Herbert Miller, Enumclaw, Washington, and Gregory Jones, Seattle, as well as from Leon Arslanian and Stephen W. Bieda, Jr., of San Jose, California.

The July 25th display was seen by Jim Frederick, Pottstown, Pennsylvania, Lawrence Heilos, Jr., Millington, New Jersey, Millard F. Wells at Frankfort, Michigan, and A. M. Germond at Stowe, Vermont. The next night Mr. Germond observed another aurora from Bradford, Vermont.

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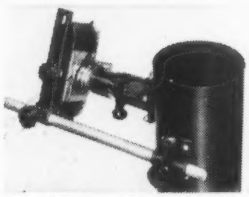

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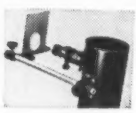

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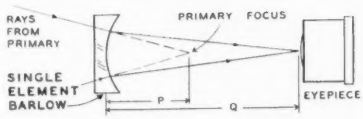

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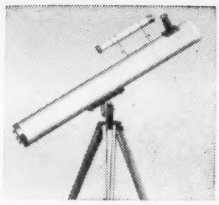

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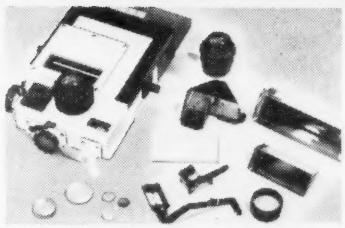

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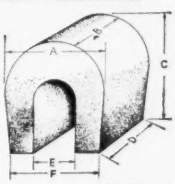

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HANDBUCH DER PHYSIK, VOL. 52 ASTROPHYSICS III: THE SOLAR SYSTEM

S. Flügge, editor. Springer-Verlag, Berlin, 1959. 601 pages. DM 148.

THIS is the third of five volumes on astrophysics, Volumes 50 and 51 having been reviewed here in February and May, respectively. All of Volume 52 is in English, except for K. Wurm's 53-page chapter on comets, which is written in German. Half of the book consists of C. de Jager's monumental paper on the structure and dynamics of the solar atmosphere. There are complete subject indexes in both German and English.

This book is a timely and fundamentally important contribution to astronomical literature. It is not, however, a complete discussion of the solar system. For example, the following topics have little or no coverage: solar eclipses, the earth as a planet, radio instrumentation, the origin of the solar system, the solar interior, the aurora, airglow and zodiacal light. Some of these subjects are dealt with in other volumes.

The sun is the easiest star to observe and thus has always been of special interest to astronomers, over and above its being vital to our continued existence. Spectroscopy in general, and astronomical spectroscopy in particular, had its inception and early development in studies of the solar spectrum. These in turn have led to a much better understanding of the stars, playing a role, for example, in stellar distance determinations by means of spectroscopic parallaxes.

The sun has the only stellar surface accessible to detailed study, and observations of its bewildering phenomena have led to the basically important conclusion that gravitational — and even radiative — forces may not be as all-important as was implicitly assumed up to a few years ago. The existence of the planets poses such fundamental questions as: How many other stars have planetary systems or habitable planets? How did these systems come into being? How can such planets be observed?

The book reflects the greatly accelerated pace of solar system study during the past 20 years. Part of this surge is undoubtedly due to seemingly irrelevant commercial and military considerations in communications, rocketry, and space travel. Since the text was written, rocket astronomers at the Naval Research Laboratory have obtained a Lyman-alpha photograph of the solar disk and have extended the observed solar spectrum some 400 angstroms further into the ultraviolet, to about 580 angstroms (see page 496, July issue). F. J. Kerr's conclusion in this book that "the detection of echoes from . . . Venus . . . would be difficult but feasible" has been recently verified by scientists at the Lincoln Laboratory, who have measured echo times to Venus with accuracies of two parts per million (page 384, May issue). We are obviously only at the beginning of a great, new exploration into the unknown.

The first chapter, "The Photosphere of the Sun," is a joint contribution by A. K. Pierce (the continuous spectrum) and by L. Goldberg (the Fraunhofer spectrum). Detailed studies of the radiation from the solar photosphere have recently made great strides by means of photoelectric and photoconductive cells used over a wide range of wave lengths. Vacuum spectographs utilizing Babcock gratings have achieved the remarkable resolving power of 600,000. Limb-darkening observations at many points in the spectrum and the absolute energy distribution lead to observational models of the photosphere that give a better understanding of the physical conditions in the sun's atmosphere. The extension of such investigations to certain favorable eclipsing stars would seem essential.

Rocket spectra show the remarkable transition at 1800 angstroms from a dark-line (Fraunhofer) spectrum of the photosphere to an emission-line spectrum of the chromosphere at shorter wave lengths. Rocket and balloon observations at less than 2950 angstroms indicate that the

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Smithsonian value for the solar constant needs revision upward. Similar observations of early-type stars, when possible, will be of great significance.

It is impossible to do justice to the very informative 283-page chapter by de Jager in a brief review. The so-called undisturbed solar photosphere and chromosphere are first treated, with attention to granulation, turbulence, the chromosphere at the sun's limb and on the disk, and the transition to the corona. The discussion then proceeds to sunspots, faculae, flares, filaments and prominences.

The corona is next taken up, from the viewpoints of optical observations and radio emissions. This is followed by a section on the sun's rotation and the solar cycle, and finally by a relatively short discussion of solar-terrestrial relationships. The references since 1953 are especially complete.

The atmospheres of the planets are considered by H. C. Urey. Their chemical compositions differ markedly from the sun's, and problems of the thin atmospheres of the terrestrial planets are very different from those involving the deep ones of the major planets. Since the formation of the solar system, these atmospheres in some cases have changed greatly, partly depending on the properties of the chemical compounds.

Urey contends that the terrestrial planets were formed at generally low temperatures, the earth by the accumulation of meteorite-like bodies, or objects such as the Imbrium planetesimal which fell on the moon. He concludes that life would probably evolve anywhere in the universe where conditions closely approximate those on earth, and that Mars and Venus are the only other known planets where life might be possible.

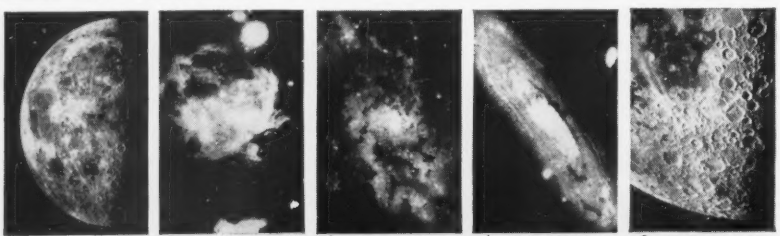
The difficult study of the interiors of planets, discussed in the chapter by W. C. DeMarcus, is more complicated than that of stellar interiors, where the properties of matter at high temperatures are relatively simple. Planetary interiors involve properties of matter at low temperatures and high pressures. In general, the pressures are too high to be duplicated in experimental laboratories and too low for the material to be in the form of a "Fermi gas," which would be more amenable to theoretical treatment.

However, earthquake waves reveal the pressure-density relation in the earth's interior, and it is often assumed that this relation holds for the remaining terrestrial planets. The composition of the earth's core is controversial. It may be iron or nickel-iron, or a high-pressure silicate phase of great density. The theoretical problem of the constitution of planets like Jupiter and Saturn is fortunately simplified, because there are good reasons for believing that such a planet is mostly hydrogen, whose pressure-density relation is quite distinctive.

F. J. Kerr writes about radio echoes from the sun, moon, and planets. Lunar echoes were first detected in 1946, the moon simulating a smooth reflector with most of the energy returning from a small area at the center of its disk. At the receiver the echo power varies as the inverse fourth power of the distance — the previously mentioned Venus echo detection was a remarkable technical achievement. Kerr gives a table which indicates that the sun, a near asteroid, Mercury, and Mars should be next on the radar list. Compared to Venus, Alpha Centauri is down in estimated echo strength by a factor of over 10^{17}.

A well-illustrated chapter by K. Wurm discusses the physics and spectra of comets, their orbits, forms, and theories of their origin and evolution. Spectrum analysis of comets is of unusual interest because the densities involved are intermediate between those in stellar atmospheres and in interstellar space.

The final chapter, by F. L. Whipple and G. S. Hawkins, is the best discussion of meteors I have seen in print. Although written on a professional level, it should appeal to many amateurs. Meteoritic research, for various reasons, has largely passed from the hands of amateurs into those of the professional astronomers, ballisticians, electronics experts, and other technical groups. Some rather firm answers can now be given to vital questions. No real evidence exists for meteors with origins outside the solar system. Ordinary visual meteors appear to be al-



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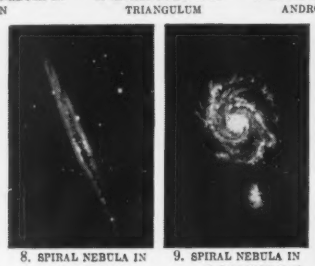

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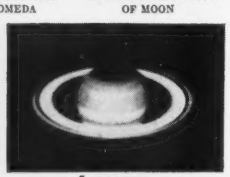

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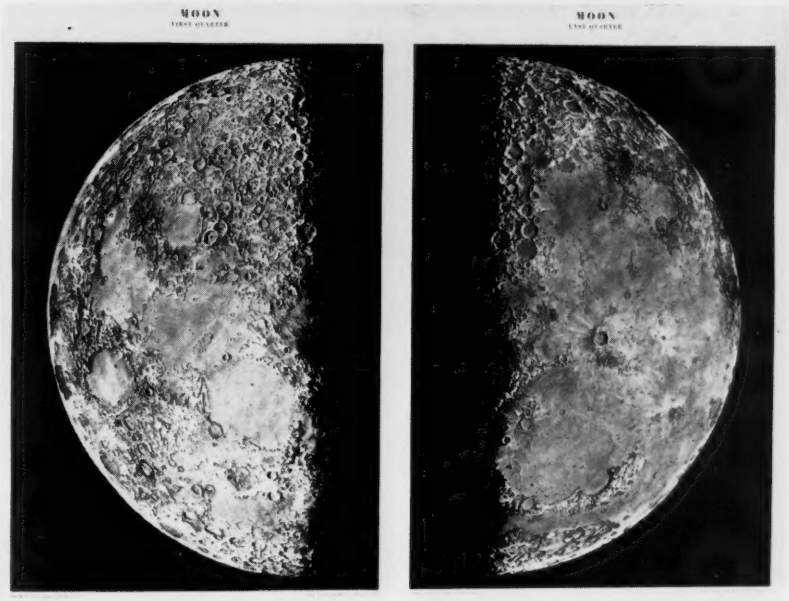

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This volume, like its two predecessors, should be on the library shelves of every university and professional observatory.

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SOVIET SPACE SCIENCE

Ari Shternfeld. Basic Books, New York, 1959. 361 pages. $6.00.

HERE is an excellent account of all phases of rocketry and astronautics written in nontechnical language and free of complex mathematics. It will make a fine addition to the libraries of students, amateur scientists, and others interested in becoming acquainted with space technology.

The volume's 11 chapters discuss and explain rocket development, construction of satellite launchers, artificial satellites and their behavior, space medicine, observation and communication techniques, re-entry problems, and current and future utilization of artificial satellites.

The author's treatment of orbits and the laws of motion pertaining to artificial satellites is good. Many tables, graphs and drawings complement the text, greatly clarifying the subject. The photographs of Russian and United States rockets and related equipment, however, are without detail and generally of poor quality, seeming to have been reproduced from halftone newspaper pictures.

Much of the information is available in other books, periodicals, publications of the International Geophysical Year, and so forth. But it is convenient to have all aspects of the subject so completely compiled in one place.

There are several typographical errors, of which the one in Fig. 37, page 132, is most obvious. There the symbols representing a satellite orbit and a lunar orbit are interchanged. In the index a few items are listed that are not found in the text.

Some readers may think that the title, *Soviet Space Science,* is a misnomer, because of the absence of material on Russian developments. Actually, this book is scarcely more informative about Russian progress in space science than are our own newspapers.

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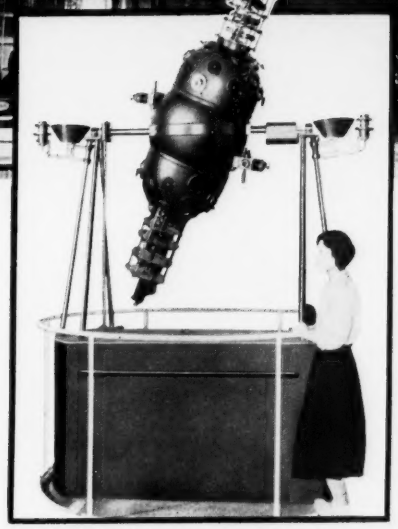

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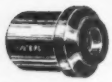

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WIDE-ANGLE ERFLE (68° field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1-13/16" aperture **$13.50**

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Pyrex	6"	60"	25.00

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The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing	Postpaid	**$12.95**
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For 4⅜" I.D. Tubing	"	**12.95**

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Same as above with coating **$32.00**
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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm. (2⅛")	254 mm. (10")	$12.50	83 mm. (3¼")	660 mm. (26")	$28.00
54 mm. (2⅛")	300 mm. (11.8")	12.50	83 mm. (3¼")	711 mm. (28")	28.00
54 mm. (2⅛")	330 mm. (13")	12.50	83 mm. (3¼")	762 mm. (30")	28.00
54 mm. (2⅛")	390 mm. (15.4")	9.75	83 mm. (3¼")	876 mm. (34½")	28.00
54 mm. (2⅛")	508 mm. (20")	12.50	83 mm. (3¼")	1016 mm. (40")	30.00
54 mm. (2⅛")	600 mm. (23½")	12.50	102 mm. (4")	876 mm. (34½")	60.00
54 mm. (2⅛")	762 mm. (30")	12.50	108 mm. (4¼")	914 mm. (36")	60.00
54 mm. (2⅛")	1016 mm. (40")	12.50	110 mm. (4⅜")*	1069 mm. (42-1/16")	60.00
54 mm. (2⅛")	1270 mm. (50")	12.50	110 mm. (4⅜")	1069 mm. (42-1/16")	67.00
78 mm. (3-1/16")	381 mm. (15")	21.00	128 mm. (5-1/16")*	628 mm. (24¾")	75.00
80 mm. (3⅛")	495 mm. (19½")	28.00	128 mm. (5-1/16")	628 mm. (24¾")	85.00
81 mm. (3-3/16")	622 mm. (24½")	22.50	*Not coated		

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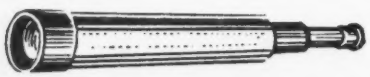

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7 x 35	341	American	23.50	—
7 x 35	578	Wide-Angle 11°	35.00	—
7 x 50	372	"Zeiss"	24.95	22.50
7 x 50	372	American	32.50	—
8 x 30	393	"Zeiss"	21.00	18.25
10 x 50	275	"Zeiss"	28.75	26.75
20 x 50	183	"Zeiss"	33.75	31.75

All prices above plus 10% Federal tax.

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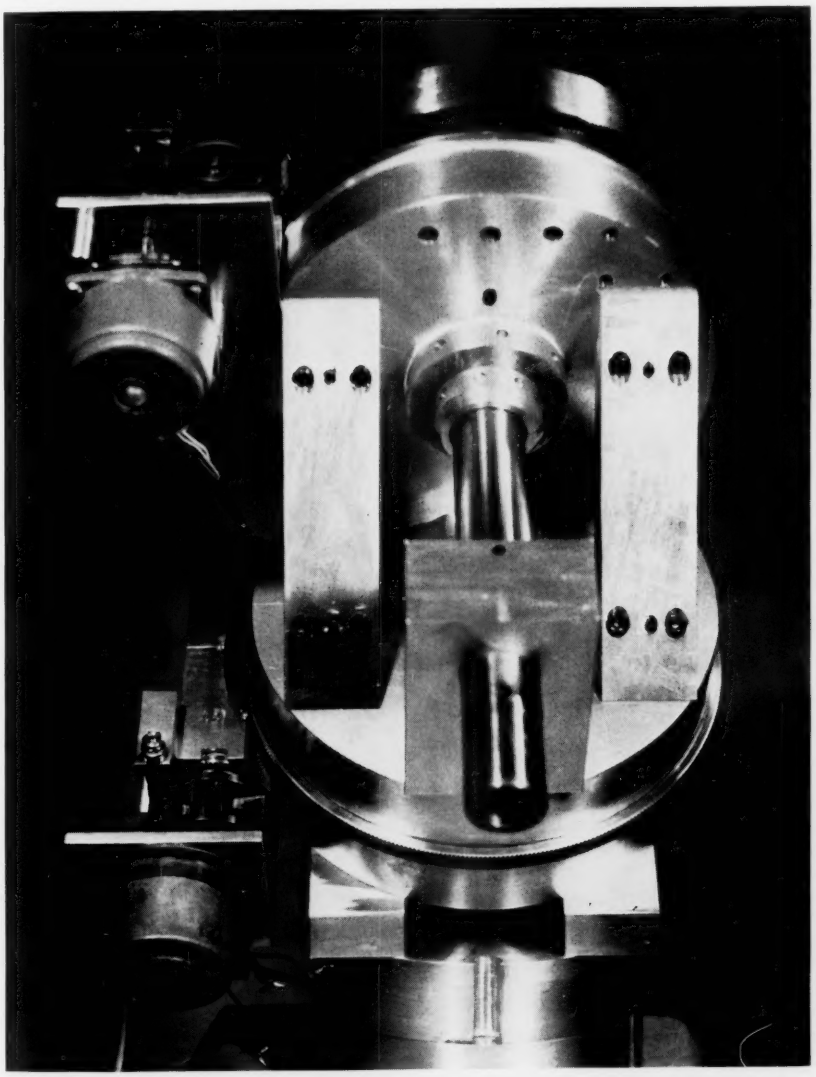
A Heavy-duty Mounting with Friction Control

THE IDEAL MOUNTING for a telescope would have a minimum of moving parts to avoid loss of rigidity because of loose bearings. But the telescope must follow the diurnal motion of the stars, and be movable in declination to point to different parts of the sky.

The nearest substitute to no bearings at all is to equip the two movements, in right ascension and declination, with bushings and friction plates that will resist all forces up to a point. Beyond this limit the friction plates will slip, allowing the telescope to move. Telescope makers have applied this principle for many years.

After discussing the matter of ball bearings versus plain bearings with Alan E. Gee, of Buffalo, New York, who has made a number of fine mountings incorporating friction control, I became convinced that the best arrangement is one that has ample friction added to the bearings and a gear-differential drive. Most motors are larger than they need to be and can overcome the additional load. For hand operation, the friction can be relieved by loosening the adjusting nuts that squeeze the friction plates together.

Made largely from discarded parts and other materials obtained from scrap dealers, the mounting pictured here has performed excellently with my solar telescope during three years of constant use (see Sky and Telescope, May, 1958, page



In this photograph of Walter Semerau's mounting, almost all of the principal parts are visible. On the left (eastern) side are the driving units for the declination gear (upper section) and right-ascension gear. The clearance at the top of the right-ascension worm allows lubrication of the unit and permits checking the meshing of the worm and gear by visual inspection.

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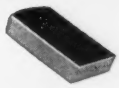

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Heavy edges to minimize temperature effects.
1¼" minor axis.
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8"	1½"	$18.75
10"	1¾"	$33.65
12½"	2⅛"	$59.95

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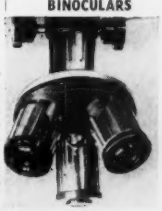

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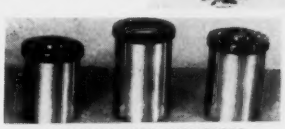

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368). Winds up to 25 miles per hour and accidental bumpings do not affect the equipment's operation. Moreover, accurate tracking is maintained even when apparatus added to the telescope causes it to become unbalanced, unless counterweights are added.

I would like to emphasize the importance of accuracy in machining the critical parts. While the machine work involved here is not complicated, time must be taken to work the parts to the required tolerances.

The first step in making the mounting was to machine down to 10″ in diameter four aluminum disks that were originally 2″ thick and 11″ across. These are labeled **1, 2, 3,** and **4** in the schematic diagram of the west side of the mounting.

Next, holes to accommodate the shafts were bored as precisely as possible through the center of each disk, the hole in disk **4** being threaded. It may be desirable, but is not absolutely necessary, to cut a recess about 0.025″ deep around these holes on one side of each disk to leave a raised rim approximately 2″ wide that will bear the thrust of the assembled instrument.

Friction disks **5** and **6,** about $\frac{1}{8}$″ to 1/16″ thick, must be identical with the four aluminum ones both in diameter and size of the central hole. These plates are best made of teflon, though nylon is also good. If these materials are too expensive for the budget-minded telescope maker, polyethylene or bakelite are reasonably priced and have given excellent service in my experience.

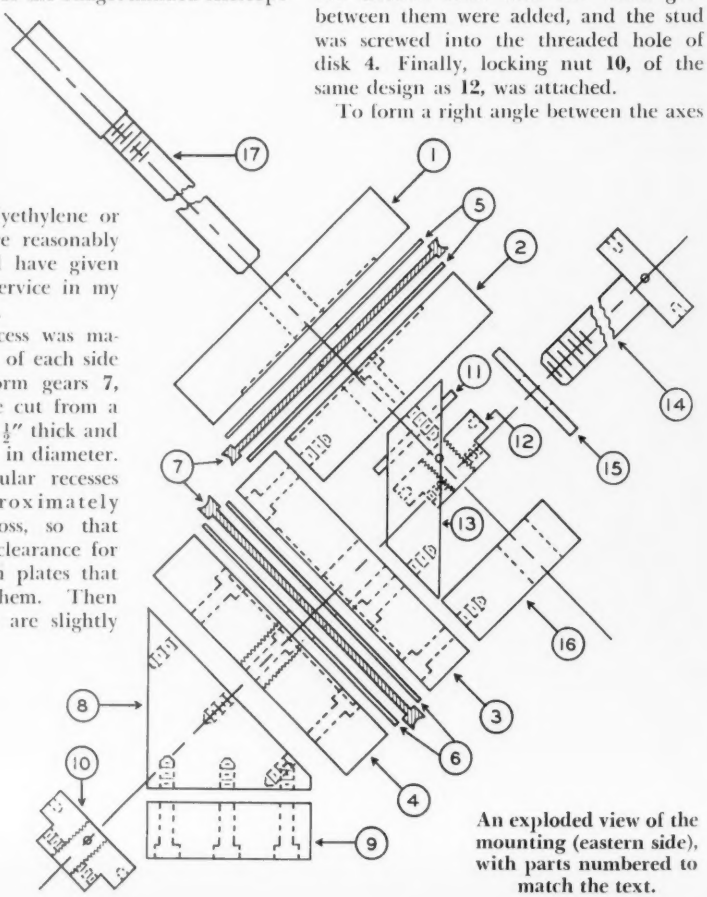
A $\frac{1}{8}$″ recess was machined out of each side of two worm gears **7,** which were cut from a brass plate $\frac{1}{2}$″ thick and about $10\frac{3}{4}$″ in diameter. These circular recesses were approximately 10.03″ across, so that there was clearance for the friction plates that fit into them. Then holes, that are slightly larger (0.001″) than the diameter of shaft **17** or stud **14,** were bored precisely through the centers of the respective gears. If the holes are too large, unwanted slippage will occur, giving the same effect as backlash in the worm-and-gear units.

The declination axle **17** has a threaded section, but its unthreaded part makes a tight press fit into aluminum disk **1** and a close slip fit through **5, 7,** and **2.** The central holes of these last three have to be slightly enlarged to permit this freedom of movement. A friction washer **11,** made of bakelite or polyethylene, was placed between **2** and the adjusting nut **12,** the latter screwing onto the threaded section of **17.** The nut squeezes the assembled parts together to obtain the necessary friction for smooth action.

To provide for locking the adjusting nut in position, drill and tap into it four holes 90° apart, and insert hex-socket setscrews in them. A lead slug put under each setscrew will prevent damage to the threads of the shaft. Eight equally spaced holes drilled around the circumference of the nut allow use of a metal pin for the tension adjustment.

For the polar axle, threaded stud **14** was machined 0.001″ smaller than the center hole in aluminum disk **3,** in order to make a close slip fit. Bakelite washer **15** was placed on the stud, then the latter was slid through the hole in disk **3.** The two friction disks with the worm gear between them were added, and the stud was screwed into the threaded hole of disk **4.** Finally, locking nut **10,** of the same design as **12,** was attached.

To form a right angle between the axes



An exploded view of the mounting (eastern side), with parts numbered to match the text.

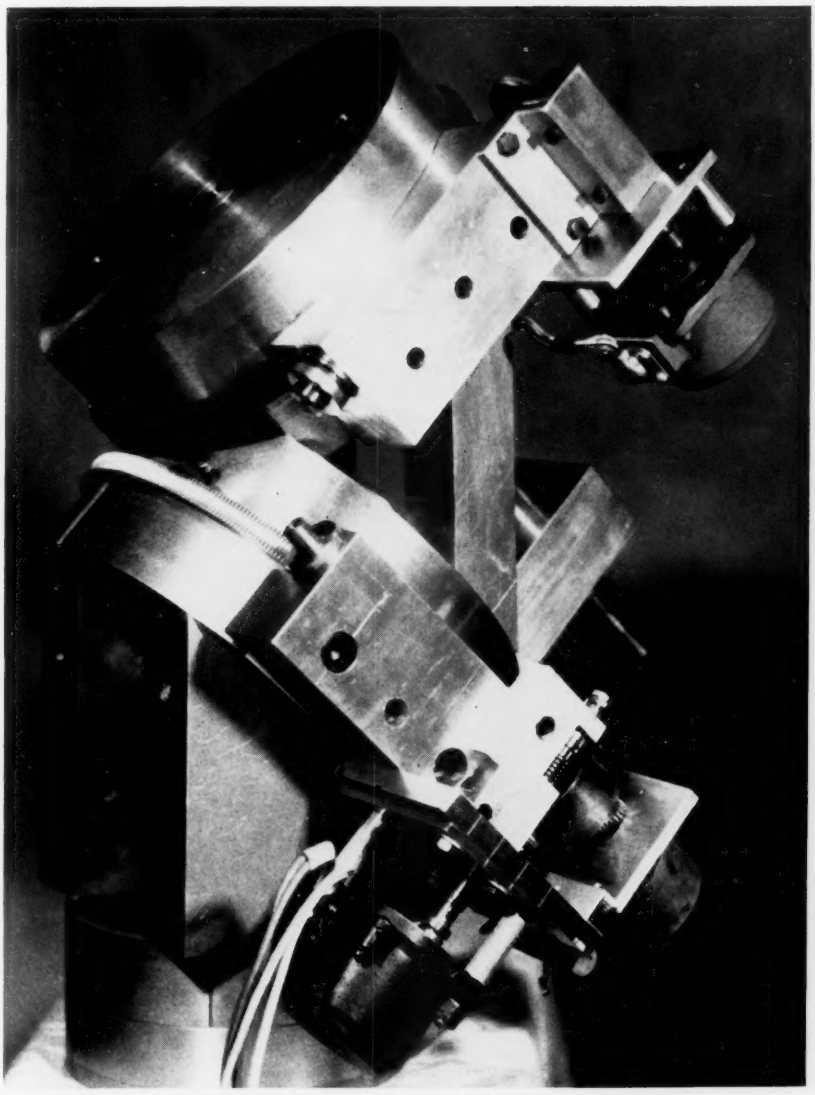
of rotation and provide a rigid locking means for the mounting parts, a chord on the lower side of disk **2** was machined flat and square. Against this the top surface of disk **3** was placed, and the disks were joined with three $3\frac{3}{4}$″ steel bolts and two steel dowel pins. A pair of diagonal braces, **13**, stiffen and align the angle, thereby preventing flexure. Block **16**, bored with a hole to make a close fit on the declination shaft, was then bolted to disk **3**, to insure against flexing of the shaft when counterweights are added.

This design can be adapted to any selected latitude by means of two thick aluminum angle plates **8**. These are milled to an angle that is the complement of the observer's latitude, that is, $90° - L$. Locking nut **10** fits between them when the mount is assembled. Both angle plates are bolted to base **9**, an aluminum disk that is attached to the top of the telescope pier.

The worm-shaft assemblies, one for each axis, are perhaps the most critical parts of the mounting. They must be properly attached to the main bearings, and operate free of flexure and backlash. The aluminum pillow blocks, **18**, that carry them are seen on the east side of both the right ascension and declination axle supports. Each pillow block is fastened to its ring (**2** or **4**) with three $1\frac{1}{2}$″ steel bolts. Flat surfaces were machined on the edges of **2** and **4** before the blocks could be placed against them.

Thin paper shims, placed between the blocks and the disks, facilitated proper alignment of the worm shafts and gears. These shims were added or removed until the parts meshed with no more than 0.001″ clearance. I like to run worm-and-gear arrangements of this type just short of the binding point.

The worm shafts **19** should be as large in diameter as possible, but not excessively



This view from the southeast shows how the pillow blocks carrying the worms are attached. The 1-r.p.m. R.A. drive motor is at the lower right, with the slow-motion servo control at bottom center. A similar motor for declination control is at the upper right. All illustrations are by the author.

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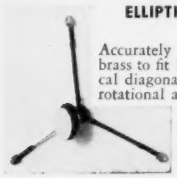

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long. My shafts are 1″ in diameter and 6″ in length, with nine threads per inch cut along the center sections. The threading must be smoothly machined, then polished by rubbing in fine abrasive with an eraser or soft wooden stick.

The pillow blocks are L-shaped, and each worm shaft fits into a 1″ hole reamed straight through the small part of the L, the clearance being only 0.001″. The ends of the shafts are tooled out to carry thrust bearings **20**, which are clamped in place with adjusting nuts **21**.

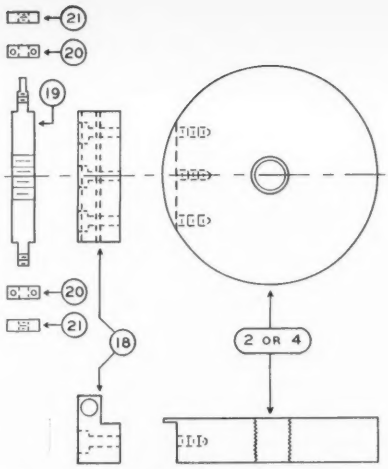
The worm shafts are the only parts of the mounting where bearings are necessary. Ball thrust (not radial) bearings must be used. Plain collar thrust bearings are unsuitable as they cannot be kept tight enough to eliminate backlash caused by end movement of the shafts.

A war-surplus differential, that may be purchased in several sizes for three to 20 dollars, is used for the right-ascension drive. One shaft of the differential is powered with a 1-r.p.m. synchronous motor having a gear reduction of four to one. This turns the polar axis at one revolution per day. The correction gear of the differential runs from a two-phase servo balancing motor geared down to a correction rate of two to six times sidereal. This speed is not critical, and an even wider spread probably would not impair the performance of the drive.

An identical servo motor is used to gear down the declination axis by the same ratio. The Brown servo balancing motors are especially well suited for automatic guiding on the sun, but for push-button guiding almost any type of motor will suffice.

There are no setting circles on my mounting, since it was designed for solar work. If circles are desired, they can easily be engraved on the circumferences of disks **1** and **3**, with pointers carried on **2** and **4**.

A heavy-duty mounting such as this one belongs on a permanent pedestal or pier. Take a 5″ steel pipe about 7′ long and set it in a foundation made by pouring concrete into a pear-shaped hole, this shape guarding against frost heaves. This will make a pier sturdy enough to support the mounting without vibration, and a good-sized telescope can be set upon this foundation.



Details of the worm and its mounting. Extremely close tolerances are necessary in the construction of this unit. For best results in alignment a precise milling job should be done on the flat faces of disks 2 and 4.

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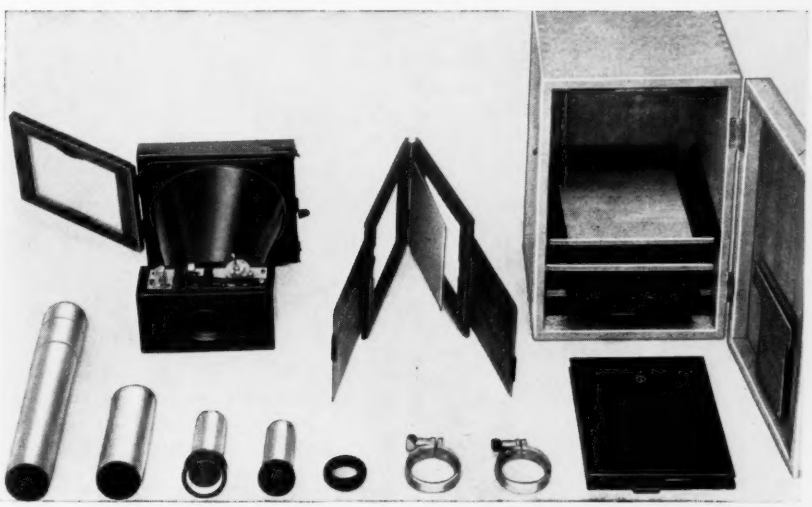

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

A Penumbral Eclipse of the Moon

As soon as darkness falls on the evening of Wednesday, September 16th, observers in the eastern half of the United States should pay particular attention to the full moon. When it rises in the eastern sky it will be passing through the outer, light portion of the earth's shadow – the penumbra. On the West Coast, unfortunately, the observable parts of the phenomenon will take place before moonrise.

The accompanying chart gives an explanation of the eclipse, showing how the moon will just miss the edge of the earth's dark or umbral shadow. At the time of greatest penumbral eclipse, however, the southern lunar limb should show a strong darkening, for it will be only a very small distance from the umbra.

In the 1959 *Handbook* of the British Astronomical Association, the following timetable is given, for September 16-17:

Moon enters penumbra	22:46.7 UT
Total eclipse begins	0:49.3 UT
Middle of eclipse	1:02.8 UT
Total eclipse ends	1:16.4 UT
Moon leaves umbra	3:19.0 UT

On the chart, the moon's position is plotted for the first, third, and fifth of these times. The umbra is plotted for mid-eclipse, and the penumbra for only the beginning and ending. The amount by which the shadow moves across the sky while the moon is passing through it is thus indicated. The position angles for the penumbral contacts have little significance, since this part of the phenomenon is unobservable, the outer portions of the penumbra having very little shadow effect.

The reader may, however, estimate from the graph the position angles when the moon is about half immersed in the penumbra, as then the first shading may be noticeable. For a discussion of the limit of visibility of a penumbral eclipse, see the article by two Kyoto University astronomers on page 620.

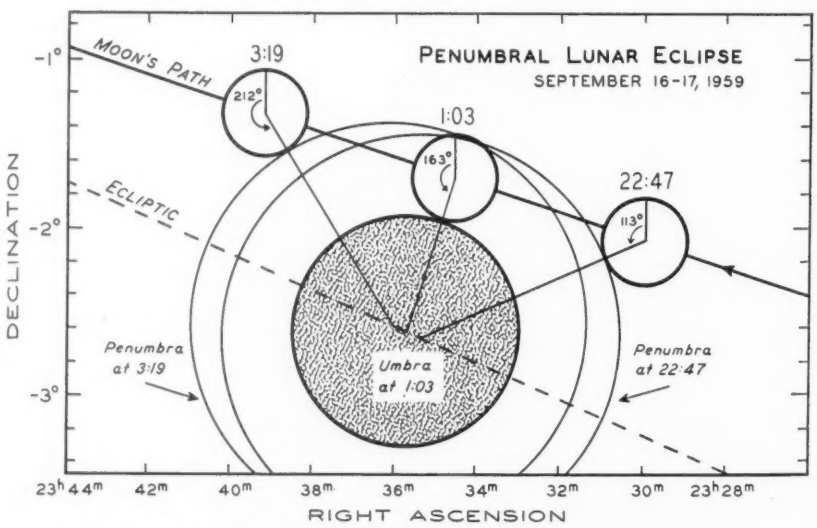
In the French publication, *Annuaire du Bureau des Longitudes,* slightly different eclipse times are predicted, and the magnitude of the eclipse within the penumbra is given as 0.988 (the moon's diameter being unity). This would indicate that the moon may not be quite completely immersed in the penumbra and that the eclipse will not be really total. The predictions depend somewhat upon the amount of enlargement that is assumed for the geometrically computed shadows to take into account refraction by the earth's atmosphere. But the slight difference cannot be determined in the case of the penumbra.

The middle of this eclipse will also be visible in eastern Canada, South America, Europe, and Africa.

MOON PHASES AND DISTANCE

New moon	September	3, 1:55
First quarter	September	9, 22:07
Full moon	September	17, 0:51
Last quarter	September	25, 2:22
New moon	October	2, 12:31

	September	Distance	Diameter
Perigee	7, 17h	229,100 mi.	32′ 25″
Apogee	23, 1h	251,500 mi.	29′ 32″
	October		
Perigee	4, 21h	226,000 mi.	32′ 52″



In this chart the events have been labeled in Universal time. Visual observers will find it worth while to use binoculars to view the slight dimming of the moon by the earth's outer shadow. The next purely penumbral eclipse visible in North America will be on February 19, 1962. However, there will be an umbral eclipse March 13, 1960.

OCCULTATION PREDICTIONS

The 20-day-old moon will occult Aldebaran on the evening of September 22nd for observers in the central and eastern parts of the United States and Canada. Immersion will be at the moon's bright limb, emersion at the dark. For the stations listed, the occultation will be roughly central and last about an hour.

September 11-12 **Rho Sagittarii** 4.0, 19:19.3 −17-55.7, 9. Im: **H** 5:55.8 −2.3 −1.9 119; **I** 5:35.8 −1.4 −0.6 85.

September 22-23 **Alpha Tauri** 1.1, 4:33.6 +16-25.7, 20. Im: **A** 4:20.0 −0.5 +1.1 99; **B** 4:23.5 −0.4 +1.4 92; **C** 4:14.2 −0.4 +0.9 104; **D** 4:19.1 −0.2 +1.4 91; **E** 4:13.8 +0.1 +1.2 89. Em: **A** 5:23.2 −0.5 +2.3 234; **B** 5:29.2 −0.6 +2.1 243; **C** 5:12.8 −0.3 +2.4 230; **D** 5:22.5 −0.4 +2.0 244; **E** 5:12.6 −0.1 +1.8 246; **F** 4:56.8 +0.3 +1.9 230.

September 25-26 **Lambda Geminorum** 3.6, 7:15.6 +16-37.0, 23. Im: **E** 10:31.1 −1.8 −1.2 134; **H** 9:54.1 −0.8 −0.1 127; **I** 10:05.1 −0.3 +1.6 85. Em: **H** 10:49.5 −0.5 +2.7 234; **I** 11:11.5 −0.8 +1.2 279.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the British *Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo,** lat. **L**) within 200 or 300 miles of a standard station (long. **LoS,** lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

MINIMA OF ALGOL

September 1, 12:10; 4, 8:59; 7, 5:47; 10, 2:36; 12, 23:24; 15, 20:13; 18, 17:02; 21, 13:50; 24, 10:39; 27, 7:27; 30, 4:16.

October 3, 1:05; 5, 21:53; 8, 18:42.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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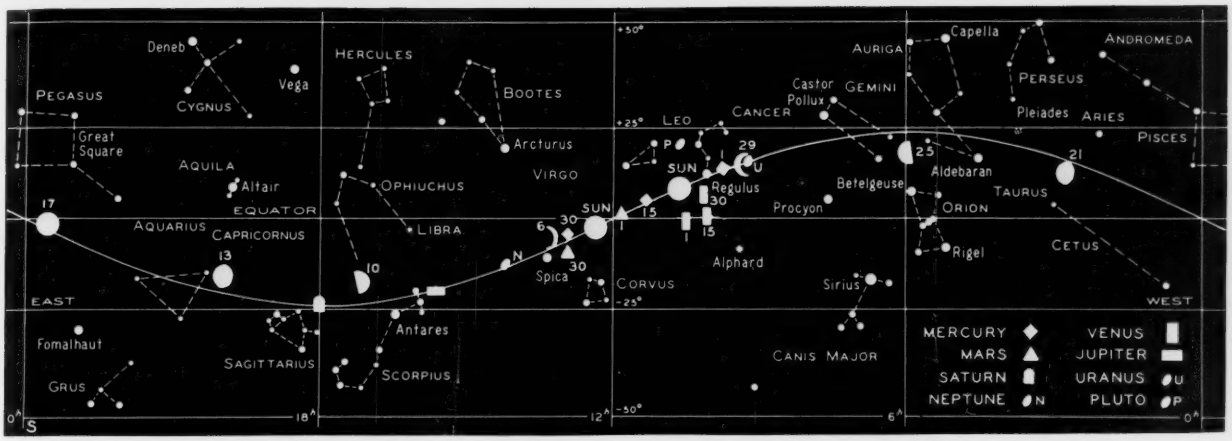


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0h Universal time on the respective dates.

Mercury may be glimpsed low in the east before sunrise at the beginning of September, by the 4th rising only about an hour ahead of the sun. Thereafter, it will be too close to the sun to be observed for the rest of the month. Superior conjunction will occur on the 17th.

Venus passes through inferior conjunction with the sun on September 1st, and by the 15th may be viewed low in the east rising about 1½ hours before sunup. At that time the planet is of magnitude −3.9, appearing as a very thin crescent in a telescope, 54″.2 in diameter and 7.2-per-cent illuminated. The moon will be near Venus on the morning of the 29th. Conjunction will be at 18:03 Universal time with Venus 2° 20′ south, as seen from the center of the earth.

The moon will pass through the penumbra of the earth's shadow on the night of September 16-17. Details are given on the facing page.

Earth reaches heliocentric longitude 0° at 19:09 UT on the 23rd. This is the time of the equinox, with autumn beginning in the Northern Hemisphere and spring in the Southern.

Mars sets too soon after the sun to be seen this month.

Jupiter can be observed low in the southwest in the middle of the month, when it sets about three hours after the sun. It is near the Libra-Scorpius border and of magnitude −1.5. In a telescope the planet shows a slightly flattened disk with an equatorial diameter of 34″.6 and a polar one of 32″.3. The moon will be near Jupiter on the evening of the 7th, with geocentric conjunction on the 8th at 9:40 UT. Jupiter will be about 3½° south of the moon.

Saturn ends retrograde motion on September 5th, when it resumes its eastward journey among the stars. The ringed planet reaches eastern quadrature on the 24th, at which time it is of magnitude +0.7 and in Sagittarius. Meridian transit is at sunset. The moon passes about 4½° north of Saturn on the evening of the 10th, with conjunction occurring at 21:56 UT.

Uranus is a 6th-magnitude object in Leo, rising about two hours before the sun on the 15th. It will then be at right ascension 9h 25m.4, declination +15° 51′ (1950 co-ordinates). It should be easily visible in binoculars.

Neptune sets about 2½ hours after the sun in midmonth, and may be seen low in the southwestern sky with the aid of a small telescope. Located in eastern Virgo, this 8th-magnitude planet on the 15th is at 14h 13m.2, −11° 34′ (1950). On the evening of September 6th the crescent moon will occult Neptune for observers in eastern North America; details for this event are given in the next column.

W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight: times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

MINOR PLANET PREDICTIONS

Ino, 173, 9.7. September 19, 1:13.9 −8-53; 29, 1:08.7 −11-00. October 9, 1:02.3 −12-53; 19, 0:55.8 −14-17; 29, 0:50.4 −15-08. November 8, 0:47.0 −15-22. Opposition on October 10.

Nausikaa, 192, 7.6. September 19, 1:45.0 +17-54; 29, 1:39.7 +18-49. October 9, 1:31.5 +19-21; 19, 1:21.7 +19-28; 29, 1:12.5 +19-15. November 8, 1:05.5 +18-53. Opposition on October 16.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

OCCULTATION OF NEPTUNE

Under circumstances favorable only for observers in the northeastern part of the United States and in eastern Canada, the moon will pass in front of the planet Neptune early on the evening of September 6th. According to the *Handbook* of the British Astronomical Association, the four-day-old moon will hide the planet at 7:24 p.m. Eastern standard time for observers at Station C, which is at Washington, D. C.

This will be less than an hour after sunset there, and a telescope will be necessary to detect Neptune (8th magnitude) in the twilight sky. But with the moon as a guide, and by means of the chart on page 173 of the January Sky and Telescope, there should be little difficulty identifying the planet.

The immersion will take place at the dark (eastern) limb of the crescent moon, in position angle 131° at Station C. Unlike the almost instantaneous disappearance that occurs in an occultation of a star, Neptune's immersion will take a noticeable length of time, the planet's apparent disk being 2.36 seconds of arc in diameter. Emersion at the moon's bright limb will be unobservable.

Sunset will be much earlier and observing conditions more favorable in New England, where immersion at Station A will be at 7:20 p.m., position angle 122°. In Canada, Station B (Montreal) and Station D (Toronto) will have 7:13, 119°, and 7:13, 122°, respectively.

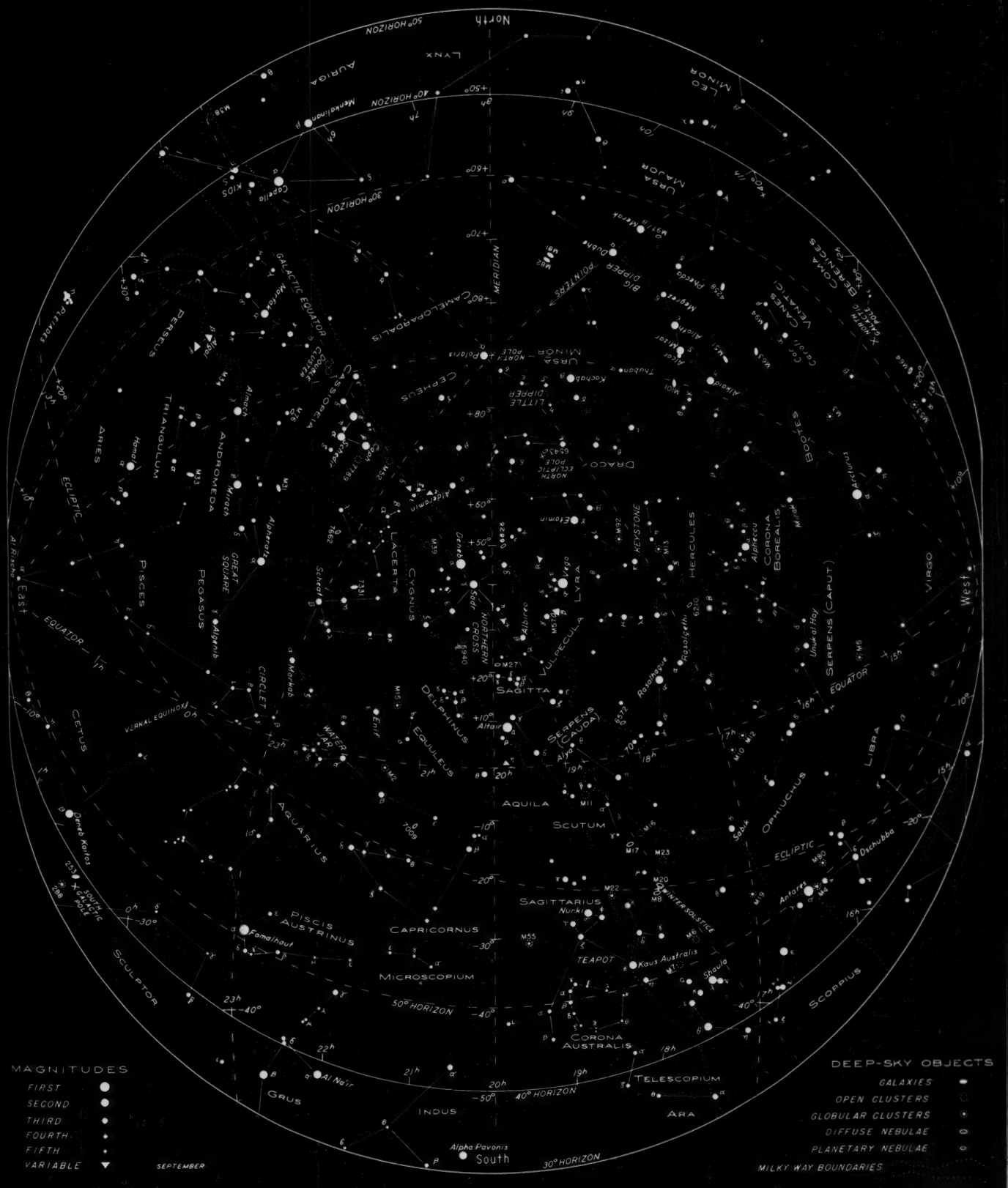
VARIABLE STAR MAXIMA

October 3, V Canum Venaticorum, 131546, 7.1; 5, RU Sagittarii, 195142, 7.2; 15, R Ursae Majoris, 103769, 7.6; 16, T Cephei, 210868, 5.8; 27, S Canis Minoris, 072708, 7.5; 31, RT Sagittarii, 201139, 7.9.

November 2, S Carinae, 100661, 5.7; 4, T Normae, 153654, 7.4; 7, RS Librae, 151822, 7.7; 7, RS Cygni, 200938, 7.4.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

South
North
East
West
MERIDIAN
EQUATOR
ECLIPTIC
GALACTIC EQUATOR
SOUTHERN CROSS
FALSE CROSS
SOUTH POLE
CENTAURUS
LUPUS
CRUX
NORMA
SCORPIUS
CIRCINUS
ARA
TRIANGULUM AUSTRALE
MUSCA
CHAMAELEON
APUS
TELESCOPIUM
CORONA AUSTRALIS
TEAPOT
PAVO
OCTANS
INDUS
SAGITTARIUS
MICROSCOPIUM
CAPRICORNUS
PISCIS AUSTRINUS
GRUS
TUCANA
HYDRUS
MENSA
PICTOR
VOLANS
CARINA
VELA
ANTLIA
PUPPIS
PYXIS
HOROLOGIUM
RETICULUM
DORADO
CALUM
COLUMBA
CANIS MAJOR
LEPUS
MONOCEROS
SCULPTOR
PHOENIX
FORNAX
ERIDANUS
CANIS MINOR
AQUARIUS
EQUULEUS
DELPHINUS
CETUS
ORION
PISCES
CIRCLET
GREAT SQUARE
ARIES
TAURUS
GEMINI
TRIANGULUM
PEGASUS
CYGNUS
ANDROMEDA
LACERTA
PERSEUS
AURIGA
CAMELOPARDALIS
CASSIOPEIA
DOUBLE CLUSTER
OMEGA CLUSTER
SOLSTICE
Fomalhaut
Achernar
Canopus
Sirius
Rigel
Procyon
Betelgeuse
Aldebaran
Rigil Kentaurus
Hadar
Spica
Arcturus
Antares
Deneb Kaitos
Mira
Menkar
Al Rischa
Markab
Algenib
Alpheratz
Schedar
Mirach
Almach
Algol
Hamal
Alcyone
Nath
Capella
Menkalinan
Kids
Marfak
Schedir
Caph
Enif
Altair
Vega
Deneb
Alsuhail
Miaplacidus
Suhail
Avior
Aspidiske
Peacock
Rukbat
Kaus Australis
Nunki
Ascella
Shaula
Rasalhague
Kochab
Polaris
Dubhe
Merak
Alioth
Mizar
Alkaid
Gienah
Algorab
Zubenelgenubi
Zubeneschamali
Alphecca
Unukalhai
Toliman
Hadar
Agena
Acrux
Mimosa
Gacrux
Becrux
Alnilam
Alnitak
Saiph
Rigel
Bellatrix
Mintaka
Meissa
Wezen
Adhara
Sirius
Murzim
Phact
Canopus
Tureis
Naos
Suhail
Avior
Miaplacidus
Aspidiske
Alphard
Regulus
Denebola
Algieba
Zosma
Chertan
Coxa
Ras Elased Australis
Ras Elased Borealis
Kornephoros
Sabik
Rasalhague
Cebalrai
Rasalgethi
Kochab
Pherkad
Polaris
Yildun
Dubhe
Merak
Phecda
Megrez
Alioth
Mizar
Alkaid
Muphrid
Izar
Seginus
Arcturus
Alphecca
Nusakan
Unukalhai
Toliman
Rigil Kentaurus
Hadar
Agena
Menkent
Acrux
Mimosa
Gacrux
Becrux
Alnilam
Alnitak
Saiph
Rigel
Bellatrix
Mintaka
Meissa
Betelgeuse

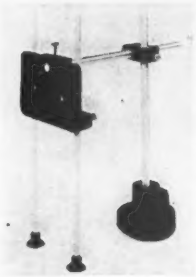


STARS FOR SEPTEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 22nd of September, respectively; also, at 7 p.m. and 6 p.m. on October 7th and 22nd. For other dates, add or subtract ½ hour per week.

Near the southern horizon are three minor constellations visible at latitude 40° north. They are Corona Australis, the Southern Crown, tucked under the Teapot of Sagittarius; Microscopium, the Microscope; and Piscis Austrinus, the Southern Fish, containing Fomalhaut.

UNMATCHED VALUES IN TELESCOPE ACCESSORIES



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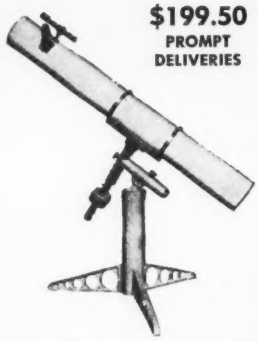

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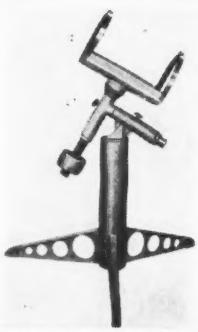

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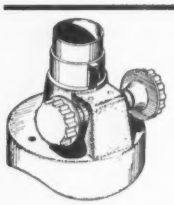

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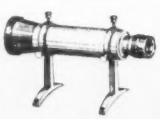

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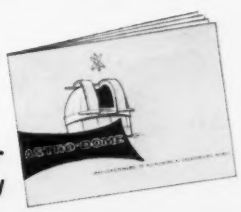

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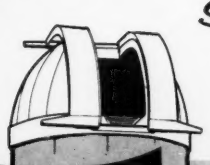

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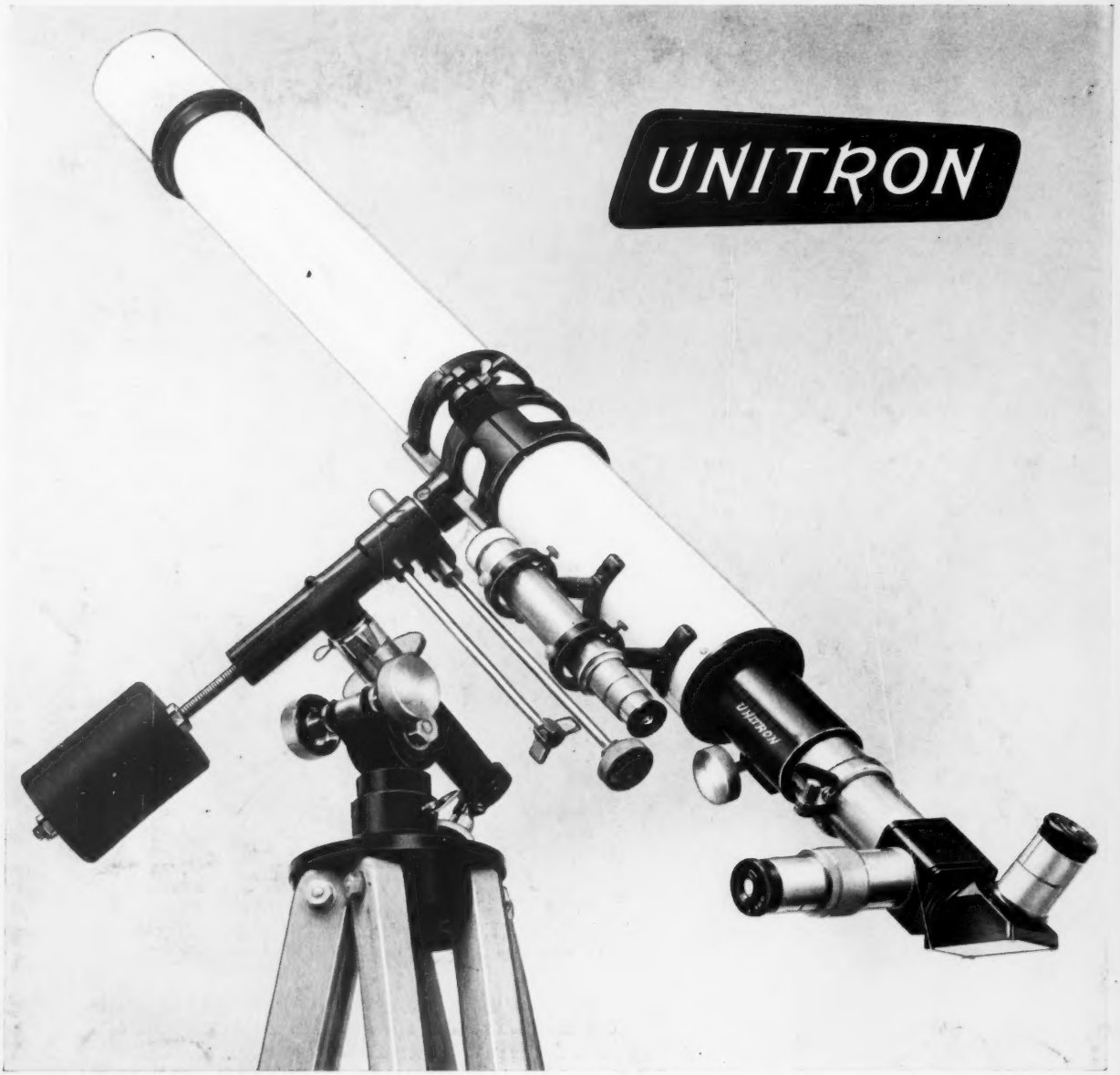

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